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ABSTRACT

This report of the DELTA (Developing European Learning through Technological Advance) Exploratory Action identifies and synthesizes the most promising findings of the 30 projects involved in the Action. The purpose of the report is to disseminate among the educational technology community the technology and services so far achieved, and to provide a mechanism to allow further development of DELTA results in the follow-up of this research action. It is noted that the original workplan of the DELTA project was aimed at improving the knowledge on all facets of the development of advanced educational and learning technologies in Europe. Chapters are as follows: (1) "The Flexible and Distance Learning Market," which covers the market structure, user's needs, producers' needs, conditions for the uptake of learning technologies, and awareness and information activities; (2) "Applications and Systems Developments," which covers learning material development, learning systems, simulation techniques, hyper/multi media, training information systems, and remote course delivery systems; and (3) "Methodologies for Delivery of Training," which covers models and methodologies, evaluation and assessment, and description and assessment of experiences outside of DELTA. Seven annexes contain: listings of DELTA projects and contact points; references to DELTA Exploratory Action deliverables and results; relevant documents issued by the DELTA office; background references; pointers to RACE projects; pointers to ESPRIT projects; and a list of abbreviations. (DB)

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**Developing European Learning
through Technological Advance
DELTA - Exploratory Action -
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Foreword

In response to Europe's growing need for flexible and distance learning, the DELTA Exploratory Action was launched by the Council Decision 88/417/EEC of June 29, 1988. This two year action was a pre-normative and pre-competitive R&D exploration in the field of learning technology. The objectives laid down by the Council Decision were to investigate the issues and potential of the harnessing of technology to the problems of life-long learning, and to consider if further actions were required. At this exploratory stage, it was necessary to assess the readiness of the main sector actors to join their efforts at a European level to undertake research, validate some initial assumptions and identify the most promising future avenues, whilst providing some tangible results.

The Final Report and the Technical Audit 1990 demonstrated that the DELTA Exploratory Action was successful in stimulating incremental research and development in the area. Some significant results have been achieved and have even led to the development of products and services that are on the verge of exploitation.

Building on identified experiences and results of the DELTA Exploratory Action, its follow up will continue to support and stimulate incremental research and technology development. This next phase of DELTA will provide improved mechanisms for the effective uptake of systems and services, better adapted to end-user needs. Future technology developments will have to be based on state-of-the-art pedagogic research and identified user requirements. Through pilot experiments and field tests, existing and forthcoming systems and services will be validated and user acceptance will be stimulated. Paving the way for the emergence of trans-European services and infrastructures for Flexible and Distance Learning is the ultimate goal.

This Final Technical Report identifies and synthesizes the most promising findings of the 30 projects involved in the DELTA Exploratory Action. In highlighting these outcomes the report aims:

- to disseminate among the learning technology community the technology and services so far achieved;
- to provide a mechanism to allow the uptake and further development of the DELTA results in the follow-up of this research action.

The exploratory research and development work undertaken by DELTA, as outlined in the original workplan, aimed at improving the knowledge on all the facets of the development of advanced learning technologies in Europe. Two years later the findings, synthesized in this report allow a greater improved insight into the potential of these technologies to convey efficient flexible and distance learning services Europe-wide.

This report will enable the broad spectrum of sector actors involved in this field to draw conclusions of major interest. Technologists, courseware producers, researchers and trainers will find the following:

- the state of the art of the harnessing of information and communicating technologies to the specific needs of learning;
- the applications and developments carried out;
- the methodologies investigated for the best implementation of learning services;
- the market trends identified;
- the factors which will play a major role in the creation of favourable conditions for the uptake of these technological innovations.

As such, the Final Technical Report is not an assessment of the individual projects active under the DELTA Exploratory Action, but a resource that should support actors in the field to design their future plans. Those who will participate in the next phase of this research will get an overview which should act as a basis to optimally harmonize their future R&D activities with the achieved results.

Luis Rodríguez-Roselló
Head of the DELTA Unit

Acknowledgements

This report is the result of the joint effort of a group of independent experts supported by the Commission staff. The report intended to synthesize the main findings of the projects' teams involved in the research and development effort in the field of advanced learning technologies in Europe: The DELTA Exploratory Action.

An impressive amount of material drawn up by these projects constructed the basis upon which the group of experts made up this document.

Thanks are due firstly, to all projects' teams who made possible with their joint work the significant advance in the field that this report is trying to describe, and secondly to the following experts who contributed to its drafting:

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Executive summary

The DELTA Programme (Developing European Learning through Technological Advance) was launched in order to investigate the issues and potential of the harnessing of technology to the problems of life-long learning. It was conceived as an Exploratory Action, to last two years, encompassing R&D work in the following action lines.

1. Learning system research

A framework for the participants, to consider targets for the programme, the sophistication and nature of teaching material being developed, and dissemination of results.

2. Collaborative development of Advanced Learning Technology

This would lead to new teaching equipment and new tools for the production of courseware. DELTA was both a stimulus and 'stepping stone' to this goal.

3. Testing and validation of communications

Testing of satellite communications, including downloading to video-recorders, live transmissions, data transmission and video conferencing. Also educational feasibility of audio and computer aided teleconferencing.

4. Interoperability

The capacity of various sets of equipment and software to work together. The aim was to encourage international, community-wide standards.

5. Creation of favourable conditions

What measures can be taken to allow the take-up of learning technology to prosper? Eg legislation on copyright, telecommunication facilities, broadcasting etc.

The 30 projects selected after a public call for proposals addressed various tasks described in the workplan. Their findings have been synthesized in this report, according to three broad categories.

First are those concerned with the understanding of the various facets of the market

and users' requirements. The second consists of specifications and prototypes of enhanced training tools using emerging technologies; in this category special emphasis was put on shorter development periods, higher quality and reduced costs. The relevance of emerging technologies, such as AI expert systems, hypermedia and the use of satellites, was also investigated. Thirdly and finally, some projects assessed different type of training delivery and some launched pilot tests of specific new technologies and methods, contributing to their assessment and to the understanding of possible implementation strategies.

1. The flexible and distance learning market and user needs

DELTA actions deal with an extensive set of actors and they have been categorised. The requirements of the users have been analysed taking into account their different training contexts. The needs of the producers of multimedia materials have been investigated at regional, national and European levels. Existing trends regarding the telecommunications applications have been analysed. A catalogue of good practices and a who's who of producers have been developed. Intermediate results have been broadly disseminated through the programme-supported newsletters. Some examples of the work are as follows:

- A network of courseware producers has been set-up, the largest of its kind in the EEC.
- Various studies contributing to the understanding of the social, organisational and cultural factors inhibiting the use of advanced learning technologies, from cross-cultural and multilingual barriers to the telecommunications tariffs.
- Several market studies are available: on the SME segment, on the transnational services with special emphasis on the special needs of peripheral regions.
- Analysis of the training pattern of apprentices in the manufacturing industry.

2. Application and systems developments

Design and production of learning material

- A full multimedia authoring system featuring simple but effective learner modelling. A full set of media editors has been developed allowing the

teacher to define a course in terms of pedagogical objectives and not in terms of computer frames. To the student it offers a "guided discovery" facility.

- Learner modelling is a cornerstone in flexible learning systems. It has therefore been addressed by many projects; eg a system by which the collection of student errors and the use of inverted dialogue allows the development of sophisticated learner models.
- Methods and tools are now available to put a tutoring system on top of any existing computer applications.
- Hypermedia technology is very promising. Extensions, such as "Conceptual mapping", were developed in accordance with learner needs; investigations were made into learning styles whilst using hypermedia.
- The design of an architecture for distributed authoring taking into account that the development of multimedia courseware no longer becomes a single person's task.
- The development of high quality multimedia material is very expensive; re-usability of units of learning material is a key issue. Consequently, a conceptual model of a multimedia database of learning material has been developed and a prototype has been created to validate the concept.

Training information system

Several developments are available in the domain of course material storage and distribution:

- An intelligent interface to give the learner easy and consistent access to training information and services plus a prototype to help the learner select courses and build his/her own curriculum.
- A database of video sequences and still images and a mechanism to distribute this material via satellite link or broadband cable.

Remote Course Delivery Systems

- Computer conferencing system able to handle text, graphics and still pictures and an electronic blackboard system allowing full duplex communication between a teacher and a remote classroom has been designed.
- An encryption system conforming to various statutory regulations, allowing maximum security for a closed user/subscription market was developed.

- A dedicated front-end for a distributed virtual classroom.

Functional Specifications and Architectures

It has been made clear that the training industry should not develop specific technical standards but select from among the existing "de jure" or "de facto" standards a coherent set that will fulfil the present and foreseeable future needs; the focus within the DELTA EA shifted towards software interoperability in order to allow the learner to access the widest range of training services.

- Some progress was made towards the portability of courseware and the interoperability of services; the feasibility of a common platform has been demonstrated.
- Functional and technical specifications of ALT standards and methods were validated with leading users across Europe.
- An inventory of telecommunication services and related standard protocols relevant to flexible and distance learning, including standards for multimedia transmission by satellites, is available.

3. Methodologies for delivery of training

The pedagogic and organisational aspects related to the delivery of training have been investigated. Some studies addressing these issues and some real life experiments, although on a limited scale, have been carried out. Both are providing a basis for future testing and further research on the delivery side. Some examples are described below.

- Experiments on computer-aided teleconferencing and on videoconference systems, with assessment of the various aspects involved, such as interactions (tutors-students, between peers) and didactic strategies.
- Experiments on the utilisation of multimedia materials, on the use of broadcasting and cable networks, with assessment of the organisational aspects involved.
- State-of-the-art studies on the added value in distance learning of new communication systems in which video, audio and data processing equipment are combined, including methodologies for delivery.
- Studies on specific related topics, such as decision making in adaptive learn-

ing and other new learning approaches and users' patterns using CAI.

- Extensive case studies of successful distance and flexible learning products and services, and their cost-effectiveness, have been gathered and assessed in order to identify the critical success factors and guidelines for future applications.

4. Conclusions

The functional specifications, prototypes and systems developed cover a broad spectrum of learning services which can be conveyed by using the information and communication technologies. They encompass the design and production process, access to information and the delivery of training courses.

The testing and assessment of the new methodologies for delivery of training has provided a better insight into the most cost-efficient ways to deliver training services using the new media. This could also be seen as an examination of how to take the fullest advantage of the flexibility and interactivity offered by the new technologies in order to improve the performance of the 'traditional' training schemes.

The Advanced Learning Technology (ALT) market in Europe, although fragmented, is better understood; the identified trends foreshadow a substantial increase in demand for products and services in the coming years. We are now close to the point at which the costs of ALT will drop dramatically thus putting education and training via telematic networks within the economic reach of SMEs and even individuals.

It is now of particular importance for the Member States to harmonise policies in the area of telematic services for education and training, and address the problem of telecommunication tariffs and the copyright protection of multimedia source material.

There is still a gap between what the technology can do and the current usage. If the R&D is to be effective more emphasis should be put on pilot experiments and implementation strategies to make real services available and targeted to a wide range of users.

Finally, the understanding gathered during this exploratory phase on all those issues influencing the uptake of flexible and distance learning services has permitted a finer targeting of plans for future R&D work. It is clearly necessary to balance the research effort between 3 major inter-related activities.

- 1. Technology integration and validation through pilot tests to allow a better understanding of the user needs and priorities and to provide feedback to R&D activities.*
- 2. Standardisation activities to improve interoperability of services, portability of products and reusability of expensive units of learning material and, therefore, attract more producers by decreasing the risks involved in the adoption of new technologies.*
- 3. Further research on the most promising technologies. This encompasses short-term research activities such as integration of simulations and some guided navigation facilities in a CAL environment and medium-term research on the basic components of an Intelligent Tutoring system: domain modelling, instructional strategies and learner material which could ultimately lead to a semi-automatic generation and, therefore, more cost-effective courses identifying with the users' needs.*

In a systems approach to R&D in ALT these three activities should be intimately linked, and particular attention should be paid to the communication and feedback mechanisms. This will finally enable an incremental implementation of Europe-wide distance and flexible learning services, based on a realistic vision of the technologies' contribution to the learning process. This approach has been fully implemented in the draft workplan, which outlines the scope and status of the future research under the action, R&D in telematic systems for flexible and distance learning.

The Report

1. The flexible and distance learning market

1.1 The market structure

The flexible and distance learning market is a new one. As such, a few vanguard organisations are using flexible and distance learning. A number of organisations have commissioned or produced customised products over a period of time and have gained much experience. Despite these experiences and developments, it is clear from the DELTA Exploratory Action that the flexible and distance learning market has hardly begun to exist in some countries of the European Communities.

There are several reasons for this immature stage of development.

New technology-based learning systems appear at the intersection of several areas: telecommunications, data and image processing, etc. There are telecommunications-based, computer-based, video-based learning systems and hybrid ones, such as interactive video, teleconferencing, videoconferencing. There are several market niches centred on such tools as television, computers, video-recorders or the telephone. The central component of the new learning configurations will be one or another of these tools depending on the context of use. The research done in the DELTA Exploratory Phase has demonstrated the diversity of possible scenarios which might develop. The research has largely echoed the difficulties raised by such a diversity of technical options: the users' equipment and the development tools are not stable; the terminology is not fixed; the users do not dare to invest in "non stable" configurations [EIOL, ETEE, OSIRIS, PRECISE, PRO-DELTA, STARTUP].

There is a fragmentation of the European actors, who compete or who may compete in the future in this market. Many small suppliers are only vaguely aware of each other. Frequently they do not compete for their potential market, concentrating instead on providing new products for specialised markets. The suppliers, including the training centres of transnational companies and in-house producers for large organisations, are not fully market-oriented [OSIRIS 1, OSIRIS 4, STARTUP 2].

On the users' side, the situation is not much simpler. The training sector is extremely

fragmented. In education, there is a fragmentation of the markets due to national characteristics in terms of language, curricula, organisations. User organisations are very diverse (and end-users even more so), their awareness and experience of flexible and distance learning vary dramatically; and their needs are extremely heterogeneous [ETEE 1]. Within the four sectors of use, simplified in the following diagram, there is an almost infinite number of users and requirements.

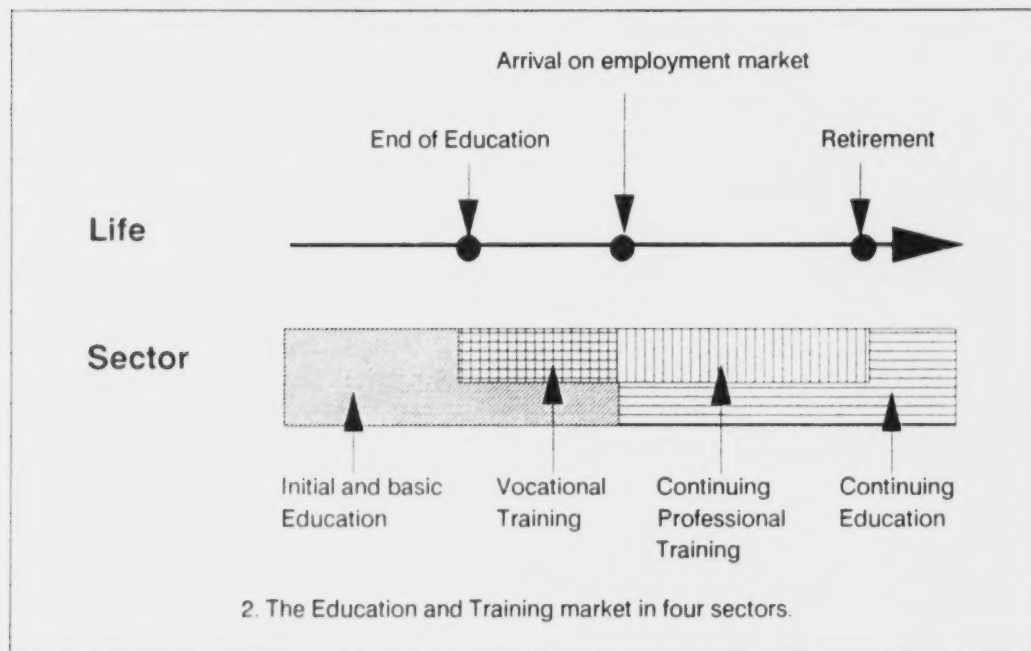


Figure 1.1: Market sectors [STARTUP 4]

Further analysis of the market shows that:

1. the education and training market is principally a market of services;
2. the purchaser is rarely the end-user: the education and training market is mainly a 'prescriptors' market.
3. future work should take into account the needs of the various individual end-users ranging from unemployed young people to professionals and the various user organisations (see section 1.2) [EIOL 3, PRECISE 3, STARTUP 4].

The difficulties mentioned in the previous section should not hide the fact that there is a substantial potential market. Indeed, it must be stated that a major expansion in the market is expected. An annual growth rate of 25% to 30% is predicted between

1990 and 1995 [OSIRIS 1 & BIS-FACT 1]. The proceedings of the workshop organised on 'markets and standards' give the following figures.

In France, the "Délégué à la Formation Professionnelle" gave a rough estimate of 60 billion FF spent in training services every year. Other sources give a figure of 53 billion FF, which would be spent by national public funding (13 billion), companies (23 billion) and the regions (2.7 billion). Training of civil servants would represent another 13.4 billion FF. Given that a significant part of this money represents the wages of the trainees, 4 billion Ecus may be a serious assessment of specific training costs.

In the UK, official sources¹ give the figure of £18 billion as being spent by employers and around £3 billion to be spent by central government on MSC training and employment measures. Given that wages would represent 75% of company spending, £3.6 billion would be spent in industrial and vocational training, around 5 billion Ecus.

Given that the UK and France represent two-fifths of the European market (this is the basis of estimation in many market studies from such sources as Dataquest, IDC, etc.), we get an approximate European figure of 25 billion Ecus. If only 5% of these expenses were allocated to new technologies, 1.25 billion Ecus would be an estimate of the market in an initial phase, even if these figures do not take into account the role of individual consumers and potential voluntary training.

We can assume such a figure to be fairly realistic, but the timescale is more difficult to predict: sometime between 1992 and 1995. Such predictions are as uncertain as those concerning the micro-computer market were before spreadsheets, filing systems, and text processors were developed and commercialised [DE2211].

In conclusion, it must be stressed that there is as yet no single definition of the potential areas of development. The projects have worked upon several definitions or taxonomies and several concepts have been shaped and used by the projects. On the demand side, Open Learning is often referred to in relation to the use of European infrastructures. It is also referred to Educational Technologies, for which specific requirements may be addressed in comparison with the technologies in use for management or other applications. On the supply side, other terminologies have been used. Such projects have been analysing the production of Technology-Based Training applications or the delivery of multimedia services, others have investigated the market for Advanced Learning Technology. Terminology is not stable because there is neither a stable supply structure nor a demand structure. This is explored further in the following sections.

1 Employment Department's White paper "Employment for the 1990's" published in December 1988.

1.2 Users' Needs

Currently, large organisations are creating the demand for flexible and distance learning, though there is a wide diversity of existing and potential users - from higher education institutions, to local training centres oriented to disadvantaged communities [EIOL 1].

For large organisations the questions may rather be ones of whether to establish their own systems or whether to make or buy-in services [PRECISE 2]. Large companies prefer stand-alone configurations with some networking facilities within the company, whilst SMEs seek to overcome distance and isolation. The results of a survey in the region of the Pays de la Loire on the attitude of enterprises towards diverse technologies were striking. On the one hand, small companies look upon the PC as a means of word processing rather than a training tool. On the other hand, large companies prefer PCs to communication tools [ETEE 1]. Large enterprises prefer in-house training models (either individual training or training departments). The main reasons for this are the control and better training results. Products developed in-house are used significantly more than out-of-house (externally produced) products [PRECISE 2]. The out-of-house products do not adapt well enough to the users' local terminology, policies and styles. The best model for in-house TBL production appears to be to set up a central training agency. SME employees, on the other hand, are trained more effectively through intermediate structures outside of the company because of time, organisation and budget constraints. These intermediate organisations not only provide access to training but also function as information resource centres and networking facilities. These organisations are only effective if they adapt the training to the specific needs of SMEs in specified regions or sectors [ETEE 1].

Small and medium-sized enterprises (SMEs), being unable to risk substantial commitments of time and money, may benefit most from the provision of public schemes and community resources. They may also benefit from relevant alliances or joint ventures with large corporations, or from appropriate organisational interfaces [ETEE 1]. Since it is obvious that the SMEs will not go to the training for a variety of reasons, training must go to the SMEs. It is a key target population because, of the 12 million enterprises in the EEC, 99.9% employ less than 500 people and provide 72% of all jobs; more accurately, micro enterprises (less than 10 people) provide 27% of all jobs, while SMEs (between 10 and 500) provide 45% [ETEE 1].

The specific requirements of peripheral regions, islands and rural areas, also warrant attention. Work has been done on the remote users' needs, for example in Portugal. Regarding these regions, it would therefore appear that the models of implementation (intermediate organisations, professional training centres outside the company, etc.), and trainers' training require particular emphasis [PRO-DELTA 1].

Emphasis on "the learner"

Finally, in respect of the analysis of the users, the focus on the learner has been emphasised by several projects.

Different types of learning (acquisition of knowledge, skills, understanding, attitudes, values and personal qualities), involve specific combinations of resources and imply distinctive learning processes and methods of assessing learning outcomes. Similarly, different types of course and training packs (awareness, general interest, up-dating, training, capability) are involved. Appropriate teaching methods are defined in terms of training aims and end-user characteristics.

Two more general points may be raised relating to this matter. Firstly, new learning materials need to attract the end-user; they must be interesting (if possible entertaining), and clearly relevant to the goals of the programme and the end-user's personal objectives therein. This raises an issue about the "openness" of flexible and distance learning. Openness may be restricted not only by cost and time demands but also by institutional requirements for end-users to have prior qualifications or to be within specified age limits. Restrictions may also derive from mismatches between end-user learning styles and capabilities and the style of materials provided [EIOL 4, PRECISE 3].

In the case of technical vocational education, the end-users need a variety of skills to deal with present and future professional settings, and must also be able and willing to adapt to changing conditions. Their most important capability is that "of learning to learn". Studies suggest that pragmatically-minded people learn best by apprenticeship with an expert - suggesting that in the future expert systems may play an important role. Requirements for such "apprenticeship-based expert systems" include emphasis on intuition, quality and "just in time", promotion of self reliance and an ability to work as a member of a team. The importance of a psychological commitment to the learning process and tools cannot be over-emphasised in such circumstances, and learning may be best accomplished by a blend of realistic computer aided learning and interaction with colleagues and experts, both of which relate clearly to the real-life challenges of the job or profession. And in order to provide end-users with understanding and adaptability, the emphasis of technology-based vocational training will need to shift from functions, procedures and the use of tools to the conceptual bases of the tasks [ARTISAN 1, EXVOC 1], supported by an in-depth understanding of how individuals and groups learn [OSIRIS 2].

This may suggest specific technical requirements. For example, many industrial training conditions include not only abstract activities but also coordination of somato-sensory inputs and outputs. The equivalent of flight simulators for industrial training is clearly

too expensive but, in the future, voice input and "virtual reality" systems may become important for the industrial training environment (including the services sectors) [ARTISAN 1].

Secondly, these and other requirements mean that close liaison between supplier and user will typically have to be part of the process of producing new learning materials. What is being supplied is a service package, not a technology, and the package will frequently need to take into account many details of the user organisation. Quality assurance systems should be implemented to ensure that suppliers, trainers/teachers, and end-users together achieve effective production, maintenance and use of flexible and distance learning systems. The organisation of such systems will be a challenging task, but will help put flexible and distance learning on a more secure basis.

1.3 Producers' Needs

Facing a diverse array of potential users, but only supplying a small number of committed users, it is no wonder that a high diversity of producers is reported. Whilst these producers share in common many needs, each has its own distinctive pattern of capabilities and requirements.

These have been categorised as follows [STARTUP 3 and 5]:

- classical publishers;
- specialised publishers;
- software houses;
- research laboratories and academics;
- training organizations;
- in-house training departments;
- cooperative associations for training.

1.3.1 The supply of integrated services

Several projects have studied one or another of these categories of producers. Interviews have been held in the corporate training departments of large companies which develop specific services for the employees. The results often confirm the trends already noted above concerning the market. They point out the fact that the provision of adequate services is essential to the matching of supply and demand of technology-based applications.

The prospect exists that generic courseware tools and modules may be used to provide

customised products by suppliers - including course developers within user organisations. However, it is also argued that generic courseware will often prove inadequately attuned to user needs. Moreover, learning materials are necessarily designed with specific use situations in mind. Sometimes technology-based materials will be used as a preparation for or refresher of a traditional course. At the very least, they almost always require back-up from trainers and tutors. These critical report staff contribute important social contacts and interaction; they can help to enhance understanding, "troubleshoot" problems, and evaluate end-user progress.

1.3.2 Issues and trends in the production process.

As well as the creation of strong links between producers and users, which has been repeatedly identified as a necessity for market development, other important assets for producers include:

- technical competence and financial capability sufficient to keep pace both with technological developments (eg. new computer platforms) and increasing user expectations for product quality;
- an improved human resources management;
- the ability to identify new potential markets, outside of one's initial geographic or economic area, where existing capabilities and products might be deployed;
- commitment to marketing;
- a reputation among potential users of being reliable and stable, in terms of product development and of long-term support. Such an image, unfortunately, may be hard to gain but easy to lose [BIS-FACT 1 and 2, OSIRIS 4].

The production process has still little clearly developed structure for the organisation and management of a wide range of tasks and related skills. In small organisations, task categories tend to be blurred (at one extreme, "everyone does everything"), but more established divisions of labour characterise the better established markets and large producers: there are trends towards more rationalised organisation within suppliers. Two models seem to characterise leading suppliers - a "project team model" which is particularly appropriate for the production of multimedia products; and an "industrialised model" which produces products in a reliable and effective way (for users who are able to specify their requirements in detail), but which may tend to result in less innovative products. A step toward these models, and away from the less mature 'author' and 'traditional publisher' models, is the "authoring team" model. This involves a group of author-designers (who can also be trainers and, sometimes, "implementors"), and can produce creative results - but the team might face problems of

internal disagreements and difficulty with deadlines [STARTUP 2].

The trends of production have been investigated by one project through 75 in-depth interviews with producers from all European Member States. In conclusion, several trends are reported:

- producers which operate on an in-house basis, for supplying internal needs, are tending to expand their production to the open market in the sector of their main activity (Education or Training) when this expansion is possible;
- producers which operate in the education sector tend to expand their production to the training sector;
- no category of producer is dedicated to the production of off-the-shelf products for the training market. However, this type of product does form a significant subsidiary activity for six out of the seven categories of producers.

The positioning of the various producers is depicted in Figure 1.

The producers display very varied levels of confidence as to the future of their particular products. Their situation is not helped by the fragmentation of the European market into national cultures not only by different languages, but also by different regulatory, education and industrial relations systems. There are, for example, concerns expressed that intellectual property rights are harder to protect out of the country of origin. Activities which could alleviate these problems - for example, through provision of better information, technology transfer mechanisms, and common standards - would undoubtedly assist the supply of new technology-based learning materials. These issues are discussed in the following sections.

1.4 Conditions for the uptake of learning technologies

1.4.1 Barriers to growth

There are several barriers to an expansion of the use of Advanced Learning Technology. The high costs of courseware development and adaptation was seen as the major reason why advanced learning products were rejected, followed by poor quality of the off-the-shelf products; lack of confidence in cost-effectiveness; difficulties of incorporating advanced learning technology within existing training practice [OSIRIS 4, PRO-DELTA 1]; and the difficulty of effective cooperation between commercial, technical and pedagogic cultures.

The costs of equipment, especially of portable equipment, which could be used in many more locations - remain a constraint to user organisations.

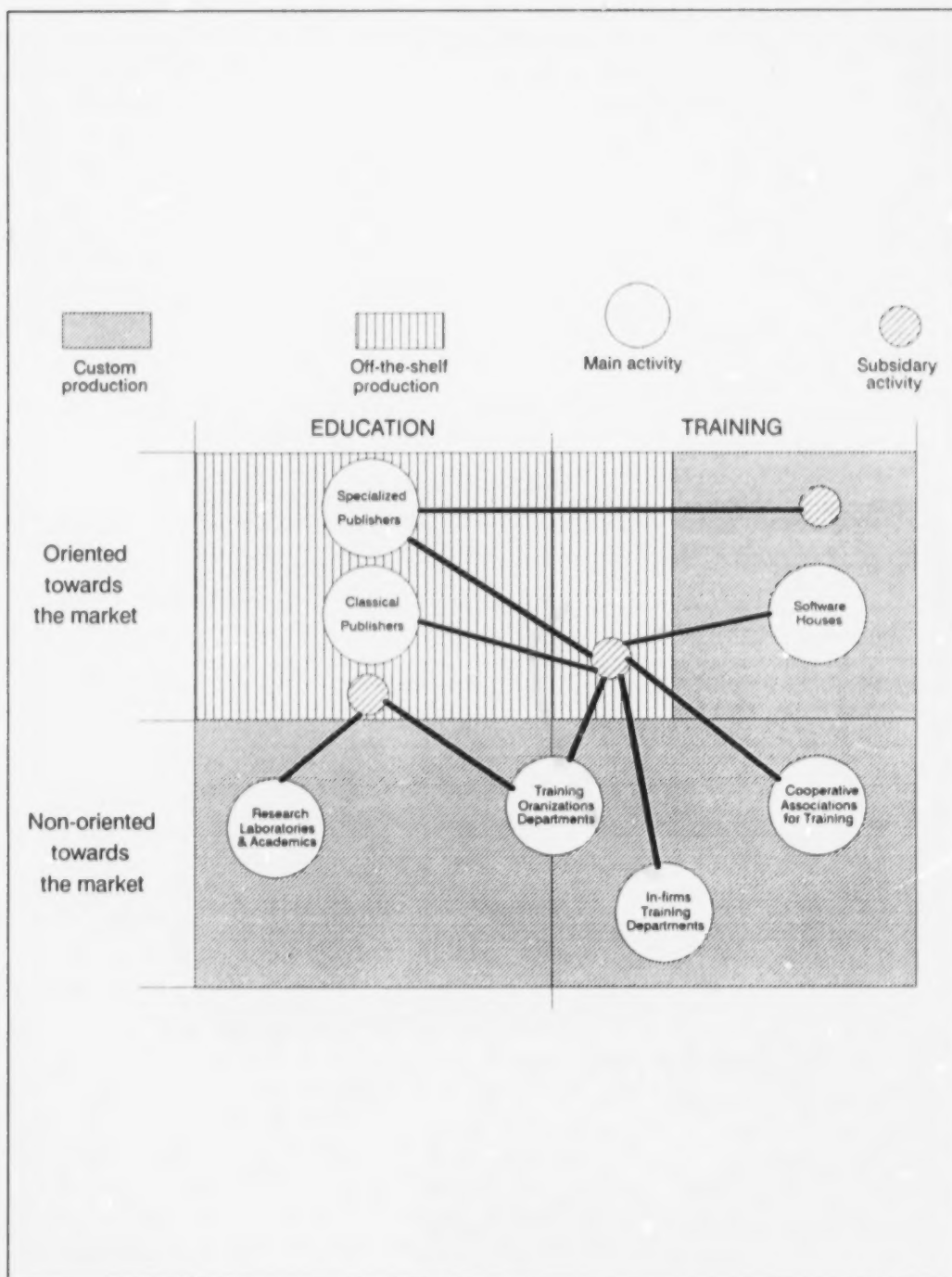


Figure 1: Market Segmentation and Producers Positioning [STARTUP1]

Costs to users will appear more manageable if the usefulness of Advanced Learning Technology can be extended, with the same equipment and, perhaps, software, being applied in different parts of the organisation. Similar material may be more attractive if it is open to updating at reasonable price, and, where practicable, if it deals with slow-changing topics. It then remains valuable for longer - though for a number of reasons, new learning materials are more often tailored to immediate needs. Efforts to achieve a longer life-cycle of learning materials have been recommended.

DELTA's studies of market developments across Europe demonstrate that, even in the most advanced countries and sectors, the markets' uncertainty is a deterrent to users making the necessary investments.

The criteria for evaluating cost effectiveness have been under discussion among the projects. The DELTA studies reveal that a common problem confronting users is uncertainty not only about the cost-effectiveness of technology-based learning - but also, indeed, about how to go about determining its cost-effectiveness. As well as initial purchase costs, a range of running costs need to be taken into account, and users need assistance in identifying these costs, in order to better appraise and evaluate flexible and distance learning before, during and after the inauguration of schemes [PRECISE 3, STARTUP 2]. As advanced learning systems are typically part of more comprehensive training programmes, these costs need to be assessed along with the costs of the technology itself [BIS-FACT 1, EIOL 2, OSIRIS 4].

Evaluation requires the assessing of cost against benefit. User experience with flexible and distance learning systems has been very mixed. The disappointments are often seen as reflecting inexperience, poor communications, and other, hopefully transitory, problems. The benefits go beyond cost savings. The new systems confer, for instance, the ability to deliver the same portfolio of material to a large number of end-users, while also being able, perhaps simultaneously, to provide material in a way and at a speed suitable for the individual. The ability of user organisations to assess benefits in terms of staff productivity, morale, and capability is likely to be determined by the extent to which they have explicitly formulated and implemented a human resource strategy. There is a range of user strategies and utilisation environments, within which flexible and distance learning may be applied to distinctive goals [OSIRIS 1].

1.4.2 The role of public policies

The fragmented structure of supply and demand together with the low ability of potential users to formulate their requirements, implies that there is an important role for policy-makers in creating the conditions for market take-off. Current markets appear to be very immature, in terms of information flows between supply and demand.

Policy intervention will need to be sensitive to the different patterns of market growth.

It may be necessary to consider which type of supplier is benefiting (some assessments see considerable scope for large international firms to enter as major suppliers); which type of user is gaining most advantage from flexible and distance learning (how to encourage small firms and individual end users), and the degree to which products on this market are generic commodities or highly customised services [EIOL 2, ETEE 1, PRO-DELTA 1].

Government and European Community support for the market can take numerous other forms, in addition to supporting human resources development - and DELTA's surveys of suppliers and users indicate that these could also be critical. Financial supports can be important: tax write-offs for firms' utilisation of technology-based applications, funds for R&D, promotion of educational institutions' involvement as suppliers and users, etc. Various non-financial measures are also important: backing for quality standards (for production of courseware materials and for end-user qualifications), for the development and promotion of evaluation and appraisal methods, and for the protection of intellectual property. As noted above, reconciling such measures across the Community will be important. Although the arrival of the single market in 1992 is seen as already boosting interest in technology-based learning, there are still formidable obstacles to trans-European activities. The social networks among suppliers and users will need to be extended across Europe - although some small suppliers need first to get to know their local markets in more depth.

Several alternative scenarios for future implementation of training have been worked out. Each scenario emphasizes one of the following options for the delivery of training within organisations:

1. *external training resource centres;*
2. *internal training structures within large companies;*
3. *outside consultants for niche-oriented training;*
4. *standard off-the-shelf CBT packages [OSIRIS 5, BIS-FACT 1, EXVOC 1, DE1715 A/B/C].*

In addition, the possibilities for a regional implementation of learning technologies have been analysed. The model of a network of SMEs coupled with a network of professional resource centres has been recommended [ETEE 1]. Such professional resource centres should provide specific training services, exchange of information and tutorial guidance. Counselling, information exchange and communication among users and suppliers are as important as the providing of training.

Trainees in large companies however prefer training delivery at the workplace through

a mixture of advanced learning and more traditional training means [PRO-DELTA 2].

Some recommendations for the implementation of a trans-European network for vocational training were given [EXVOC 1].

Given the generally immature state of the market, and the relative lack of experience with flexible and distance learning, users need to be assured of the competence of suppliers - of the ability of suppliers to correctly represent and deliver quality products which match user requirements. Interchange of experience among users may play a useful role in helping them select suppliers.

The awareness and information activities which have been carried on in the context of the DELTA Exploratory Action, are particularly important for the uptake of the market.

1.4.3 Standards for emerging market requirements

Standardisation, portability and interoperability are prerequisites for an effective and economic learning market. Standardisation should be both technology and market driven and based on existing and emerging standards and conventions. In several areas, it will be necessary to define new specific standards and conventions for educational technology over and above those already existing. One major problem identified here is that those standards which are behind proprietary innovations are often defined with no involvement of end users. These topics are discussed in part 2 of this report.

Two different approaches and viewpoints have been researched within DELTA:

- Multi-perspective view on Advanced Technology Learning (ALT) standards based on user requirements [OSIRIS 1].
- Standardisation of ALT from a technological viewpoint (eg. the DELTA project [LEAST 1]).

It became clear during the DELTA EA that in order to clarify standardisation processes, one had first to clarify the user requirements. Currently expressed requirements are the basis of current standards and emerging requirements, the basis for future standards a survey on future needs [OSIRIS 1] emphasised the following points:

- Products should be learner-oriented;
- Technology should be reliable;
- Technology should be user-friendly;

- Technology should be compatible with existing IT systems [OSIRIS 1];
- Technology should complement traditional media, eg. paper and video which play a major role in distance learning [PRO-DELTA 1, DE2211 and OSIRIS 1];
- Market formation would be enhanced by the development of a standards reference model, based on Open Systems Interconnection [OSIRIS 7].

Technical standards by themselves are less of a priority for DELTA; they should be considered as just one of the levels of standardisation.

The first level of standardisation is a common language/understanding of the learning technology space. The idea of a common language is more embracing than the achievement of a common terminology which issues from more technical concerns. The reason why such a common understanding is so difficult to achieve is that learning technologies deal with one of the most difficult conceptions: the nature of human learning, both individually and collectively.

Such a common understanding gives rise to a common terminology and a common framework. Both OSIRIS and LEAST came up with a reference framework: OSIRIS developed a high-level architecture defining the roles of the technical system within both the socio-technical supply system and the broader demand environment. LEAST developed a technical framework situating the functions of the different actors.

The two lower levels are more technology-related: guide-lines for courseware design and use and pure technical standards (de facto standards and those recommended by the standards bodies).

Common understanding, common terminology and framework for standards should be emphasized within DELTA; guide-lines and standards should be derived from other disciplines and research programmes (RACE, ESPRIT) and provided as input to DELTA projects.

In general, it was felt that from the stand-point of DELTA, little could be done to influence the standardisation procedure at the level of the activities of standardisation bodies. But DELTA could do much to bridge the gap between technology markets by concentrating on user demands and achieving the necessary interoperability [DE2211].

1.5 Awareness and information activities

1.5.1 Raising the users' awareness

Several reports and projects have contributed to the raising of the users' awareness [EIOL 1, PRECISE 3]. 19 case studies have been produced in order to provide examples of the implementation of learning technologies. 12 have explicitly addressed the presentation of "successful" applications. These case studies are partly related to the SATURN network, which involves 90 users of "open learning" in Europe. They will be disseminated through this network and beyond.

These findings have contributed to the identification of at least three types of "market information". One, understanding of the training goals and problems of user organisations. Two, understanding of how technology-based applications can fit into users' existing training systems and be used by their current trainers - or of how trainers might accommodate themselves to changed circumstances. Three, understanding of the pedagogical characteristics and needs of the end-users, and of the learning situations and processes in which they participate.

1.5.2 Raising the producers' awareness

Access to means of gaining a good understanding of the market - which essentially means good user-supplier communication links - is a key requirement for suppliers. In analysing the production process and in developing a network of producers, the largest of this kind in Europe, the STARTUP project has taken an important step in terms of raising the awareness of the suppliers regarding their own strengths and weaknesses.

The work on good practice, the hosting of a symposium of European producers, and the creation of a suppliers' "Who's Who" have contributed to this network of suppliers. The Who's Who, available in D-BASE form (732 records), is the result of the survey carried out by seven partners, in charge of covering all Member States. It provides information on the types of companies, the sectors and the nature of the learning materials [STARTUP 3].

1.5.3 Information dissemination

Several other DELTA activities have a high orientation towards creating awareness. A "DLT NEWS" has been regularly published, with news from the DELTA projects, from the Commission and from other sources [INTERMAPS 1]. The core information of the newsletter has also been published in an electronic format on the EUROKOM teleconferencing service, with an average of 500 readers. This experimental service

investigates the interest of electronic fora for facilitating awareness and information dissemination through trans-European electronic networks [INTERMAPS 2]. In parallel, the project in charge of this newsletter has published two multimedia magazines, both with a video cassette.

1.5.4 Associations and networking

The European Learning Technology Association (ELTA), aimed at an international audience, was launched in The Netherlands, under the stimulus of the DELTA Exploratory Action [PRECISE 5].

A survey of 12 existing associations was made by one project, under the stimulus of its prime contractor (SATURN) in order, firstly, to test the knowledge of each association regarding the others and, secondly, to increase the potential for further interworking and collaboration between those associations [EIOL 4]. This may be a first step towards further actions.

There is no one single approach to the applications of technology to learning: there are many different technical and social solutions imaginable. A major aim of awareness activities must be not to prescribe a single formula, but rather to enhance decision-making about these alternatives. The use of advanced technology in education and retraining has a long and chequered history. But there is now much evidence that good practice can result in success: and there are encouraging signs that enhanced awareness can accelerate market take-off. Such a take-off, the great majority of suppliers and existing users agree, will develop sooner or later. The full realisation and wide distribution of the accompanying social and economic benefits thus moves onto the agenda alongside and as part of creating the conditions for take-off.

2. Applications and systems developments

2.1 Learning material development

2.1.1. Functional Specifications and Architecture

As several actors are involved in the learning development process (publisher, author, tutor, learner, etc) a need arises for some common tools and for some standardisation in order to implement effective cooperative development.

As a reaction to the current lack of quality multimedia tools within existing authoring systems, a currently observed trend is the development of courseware material towards the use of hypermedia generic tools. However, in this case, a pedagogical approach is missing. In both situations, a semantic layer is missing which prevents the implementation of any didactic strategy.

Producers complain about the non-existence of a single, integrated, tool capable of covering all needs [STARTUP 1].

There is still discussion on the scope of the integrated system, the main issues being:

- the separation or the integration of the authoring and of the learning components;
- the possible introduction of AI concepts in one or both of these components;
- the re-usable methodologies and/or data.

2.1.1.1 Advanced Architectures

Authoring a multimedia learning material is no longer a task for the individual; it requires the cooperation of a number of specialists i.e. the domain expert, the course designer, the media experts.

A general model of the development process for multimedia courseware was de-

veloped, taking into account the user interface, a knowledge-based adviser, an integrated authoring tool, a multimedia database and communications. It contains a description of the conventional steps in learning material development and evaluation [CAMCE 2].

In this distributed environment, the cooperative development is an integral part of the overall architecture. A prototype was developed linking LANs by ISDN or satellite links [CAMCE 7, 8, 9 and 10].

The architecture encompasses a systematic approach to the multimedia courseware development. A process-oriented model is used to define the development in terms of phases, activities, tasks, information flows and data-structures [CAMCE 5 and 10].

An alternative solution to a single integrated tool is based on the principle that learning material development can be described as a series of transformations of so-called "deliverables". From this point of view, it is not very important which tools are used to create these deliverables, as long as deliverable types are carefully defined, inter alia, by the characterisation of their syntax and semantics. This solution proposes an open architecture in which sets of authoring tools can cooperate and to which "meta tools" can be added for tailoring the environment and for guiding tool users (Learning Material developers) [SAFE 25, figure 2.1].

Besides these global solutions that may incorporate AI concepts within both the authoring and the delivery components, alternative solutions are proposed when considering specifically only one of these two components: at the level of the authoring component, a knowledge-based adviser; at the level of the delivery component, a simplified learner model (see below 2.1.2).

Another approach, putting much emphasis on the producer's view, is described in [EPOS 16]; the underlying courseware model features the re-usability of units of learning material (ULM) and the multi-functional use of a course module, for example:

- access mode derived from the book metaphor (table of content, index, markers);
- access mode defined by an instructional path;
- user-defined access mode;
- personalisation .

In addition, this approach takes into account the specific requirements imposed by the remote delivery mode:

- portability on a wide range of OS platforms;

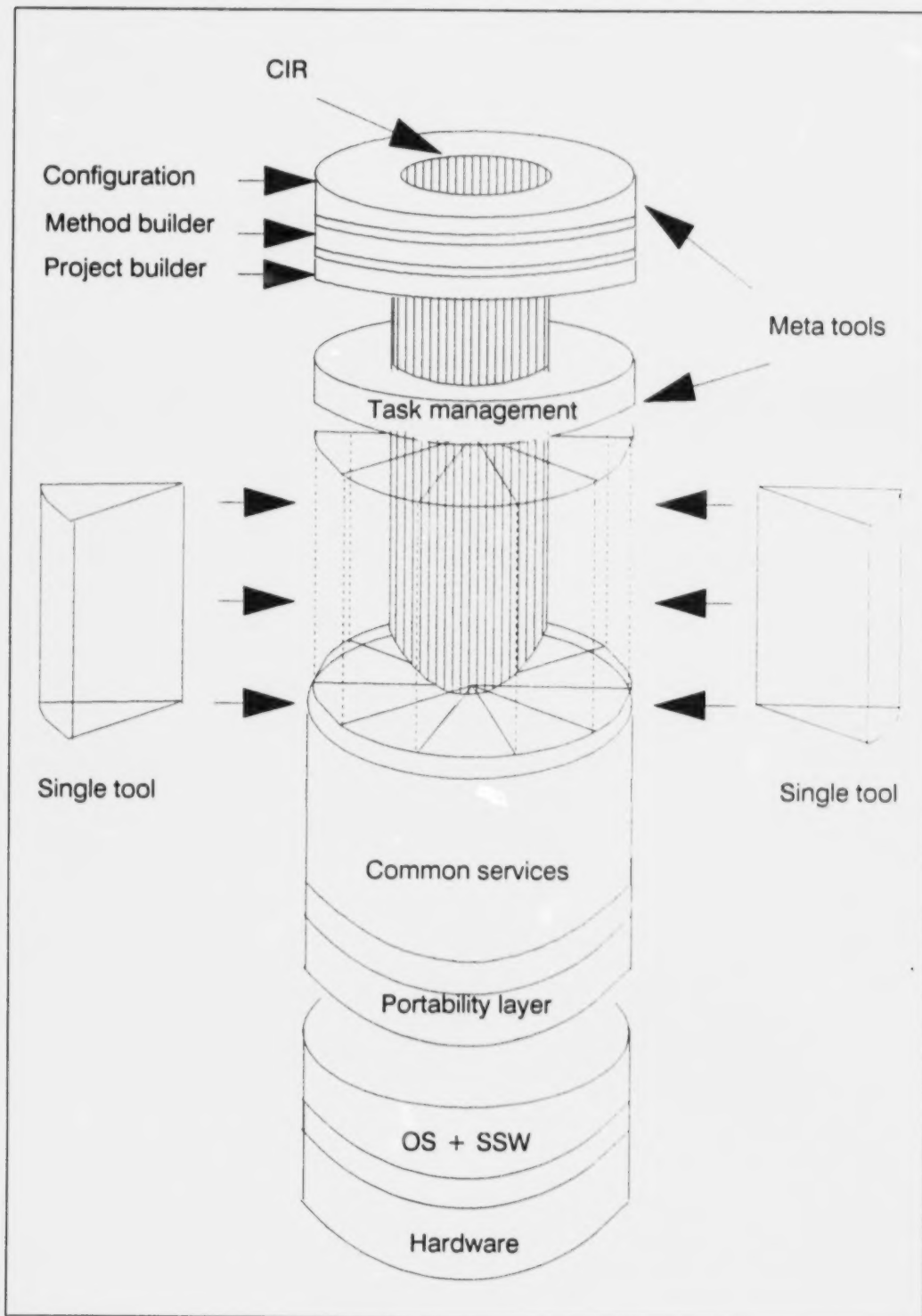


Figure 2.1: OS-ID Architecture [SAFE 25]

- dynamic downloading of ULMs;
- usage monitoring etc.

An original approach addresses the specific problems of tutoring and monitoring of existing computer applications: some applications (third party) cannot be modified, each application has a specific interface and a specific set of concepts needed to explain it. In this context, a training system must be able to "monitor" the performance of the learner in order to provide the necessary feedback and corrective action. The architecture of such a system, for which a prototype has been developed, is quite particular as it incorporates a "filter" to intercept the interaction between the user and the application [TMIE 2], figure 2.2.

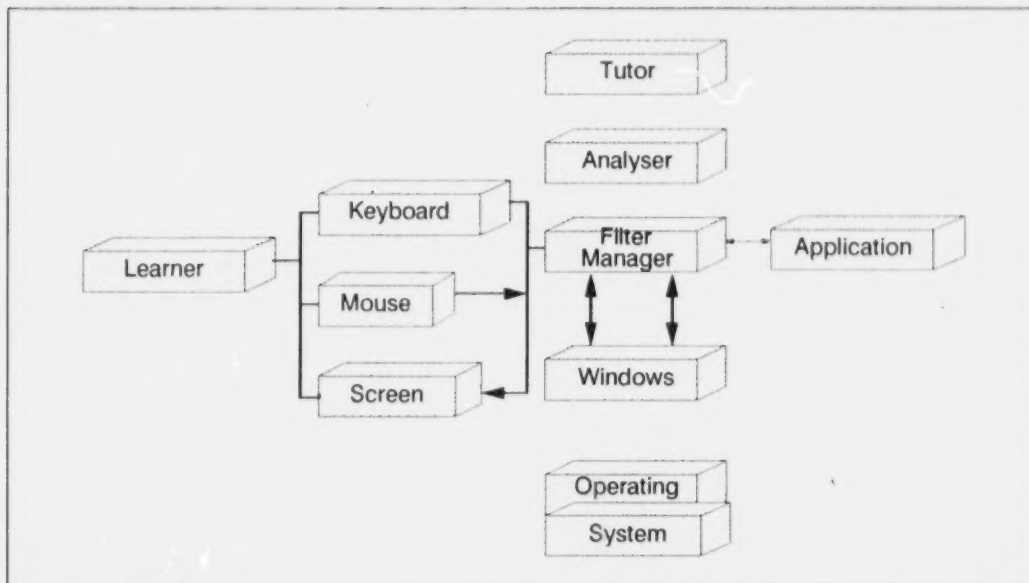


Figure 2.2: Tutoring/Monitoring added to third party application

2.1.1.2 Standardisation

This area of work encompasses some of the most important issues for learning technology: portability, interoperability and standardisation.

A significant conclusion to emerge from the Exploratory Action was the role of the DELTA programme in the standardisation process. It is possible to conceive of this process as:

- development of common understanding and terminology;

- development of common frameworks;
- development of functional requirements;
- development of formal specifications;
- development of draft standards;
- adoption of standards and/or guidelines.

The joint recommendation of the various DELTA projects involved in this area was that, within DELTA, the emphasis should be on the first three steps of this process, and that guidelines and standards, particularly in the technical arena, should be derived from other disciplines and research programmes, such as RACE and ESPRIT. DELTA technical developments should be based on existing and forthcoming international standards. In particular, the need for adherence to common practice was identified for the following fields:

- telecommunications;
- disk and file formats;
- user interfaces;
- tool compatibility;
- data structures;
- half fabricates;
- learning material templates;
- terminology.

The objective was to provide portability, re-usability of material, cooperation and interoperability between the various actors.

A review of the issues and of existing technical standards relevant to DELTA has been made by the DELTA office [DE1715 A/B/C] and by individual projects. A review of the issues addressed and of the objectives of these projects is also included in DE1715 A/B/C. An important aim in each case was the promotion of a common understanding and terminology.

In relation to the development of common frameworks several avenues have been explored.

One project [ASAP 3] has adopted a general software development view of the technical support system which meets the objectives outlined above. It envisages a common technological environment which satisfies the requirements of application developers, and at the same time provides tools for accessing the developed applications by learners, authors, training managers and others.

The architecture is based on an object-oriented development environment linked to database support, communications support and presentation software. The high level interface for users adopts a hypermedia style. This architecture has been implemented on several "industry standard" platforms, and the portability of applications developed for each of them has been demonstrated, figure 2.3.

A different starting point to the achievement of the listed objectives has been taken by another project [ESSENTIAL 2]. It started with a study and then there was a series of workshops, on the methods in use by the European training industry [ESSENTIAL 3]. This has led to the concept of a Learning System Life Cycle, incorporating:

- planning, conceptualisation;
- product development;
- commercial production;
- distribution and product support;
- selection and delivery;
- tutoring and monitoring.

The next stage was to build up a taxonomic framework and a requirements model for the technological tools in use or requested by the practitioners. This was followed by the development of a methodology for the functional specification of learning system tools, based on enterprise modelling. Formal specifications were put forward for common, authoring and production and delivery tools [ESSENTIAL 1 to 7].

These specifications and requirements led to the definition of an initial embodiment of a common support environment, including recommendations for the use of appropriate standards and architectures in order to achieve portability, interoperability and usability [ESSENTIAL 8].

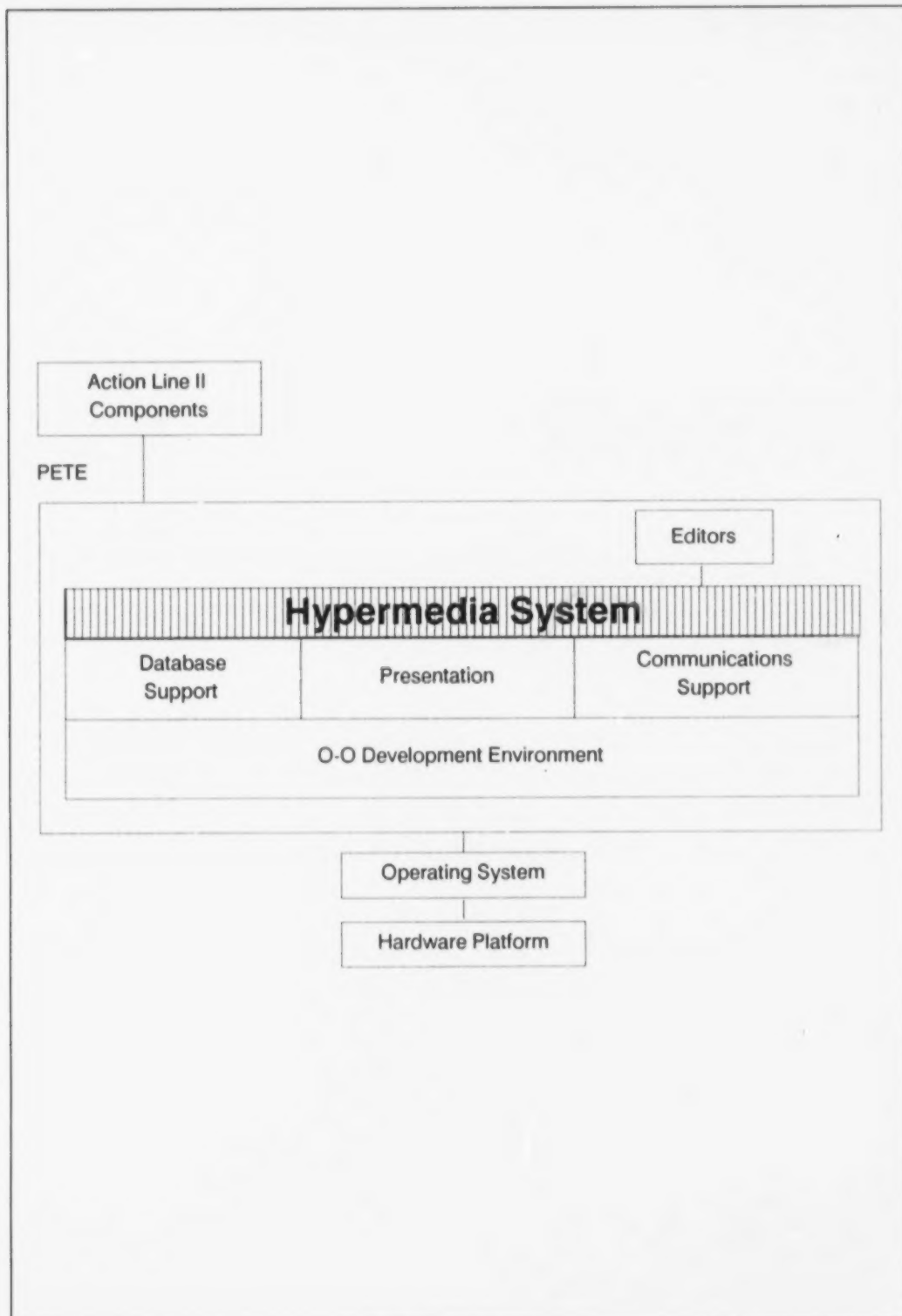


Figure 2.3: The ASAP Prototype System [ASAP 2]

This approach has not, as yet, been tested by means of a practical implementation. It represents a "top down" methodology, which contrasts with the pragmatic "bottom-up" approach of the ASAP project.

A more technical "bottom-up" approach to the development of functional specifications has also been explored, this time in the context of computer based training systems [LEAST 2]. It has not explored the views of a wide range of users and developers but proceeded from its own experience and awareness of technical constraints and standards. It has also placed considerable emphasis on a French draft standard for the interchange of interactive audio-visual applications (RAVI). The work has resulted in the development of a theoretical framework (Learning System Reference Model) [LEAST 1] and the identification of existing standards relevant to it.

The relationship between the process of standardisation and the markets for Advanced Learning Technology has also been explored. The project [OSIRIS 3] has come to the view that sustained growth of the European market requires the development of not only technical standards but also a harmonisation of the organisational and institutional approaches to the application of ALT, which determine its "added value". Although it was not a specific objection, several "technology development" projects contribute significantly to the overall standardisation process by identifying some potentially relevant areas and by their contribution to the process of developing a "common understanding and terminology" and a "common framework". Lets mention here AAT who bridged the gap between ITS and frame-based system (see 2.1.2.) and layed down the foundations for a common framework. ESM-BASE who made explicit the various roles that are relevant to educational computing systems (see 2.1.2.2) and developed a methodology relevant to the standardisation issue.

2.1.2. Learning Systems

The frontier between Intelligent Tutoring Systems and Computer-Based Teaching is becoming fuzzy: intermediate solutions are proposed which are less complicated than the Intelligent Tutoring Systems and based on elementary learner models and on declarative knowledge representation (ECAL). An example of an ECAL system is the SHIVA prototype developed by AAT: it involves adaptive and dynamic decisions concerning the ordering of the material presented to the learner this approach clearly demonstrates that the progression from rigid frame-based system to "intelligent" systems can be incremental. The author does not define the sequence of frame but the links between high-level concepts underlying the course to be taught and the multimedia frames, which is done by using the "PSAUME" editor (see figure 2.4).

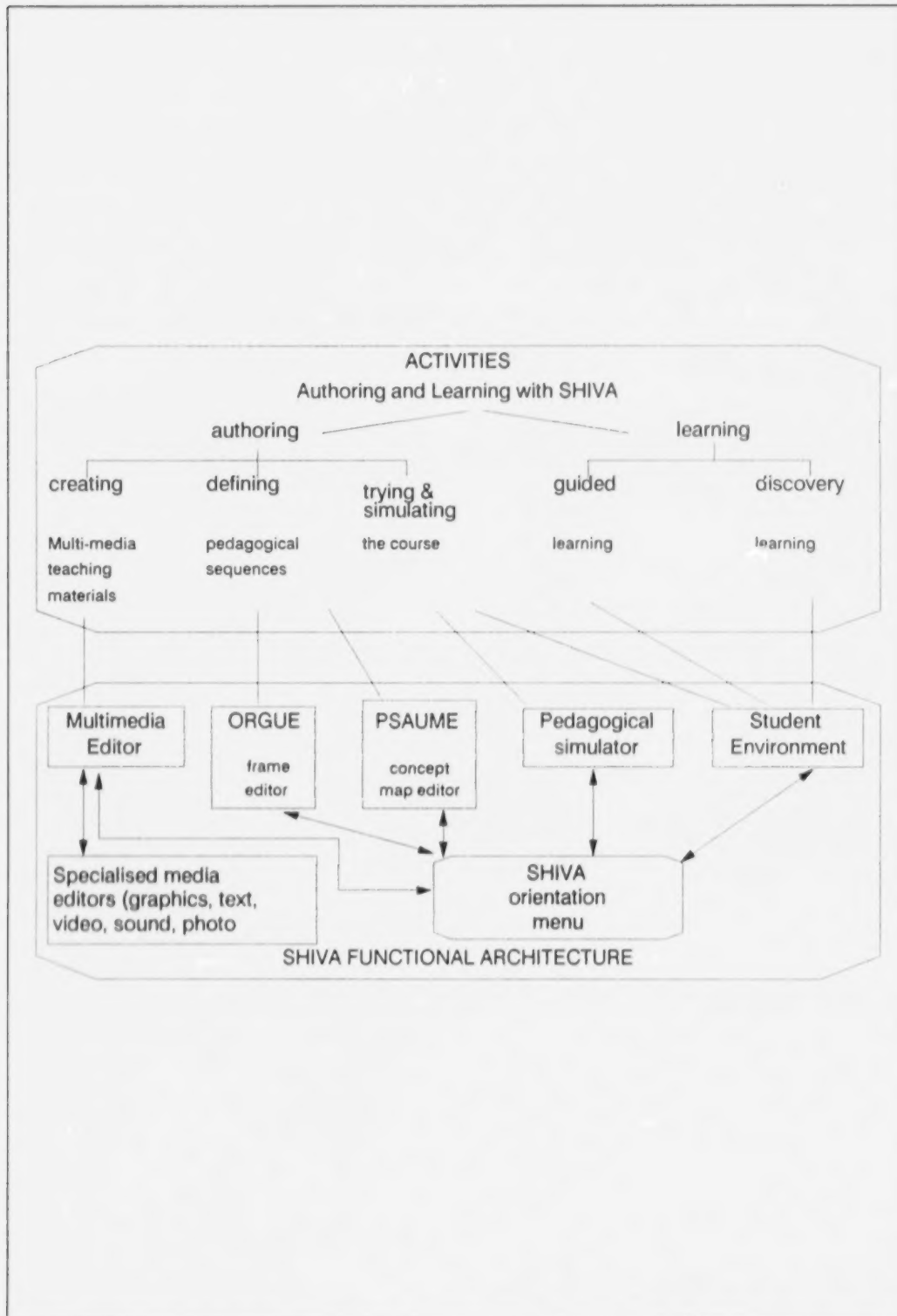


Figure 2.4: SHIVA Functional Architecture [AAT 1]

In traditional Computer-Based Teaching, a trend was observed in developing authoring systems, aimed at reducing the cost of courseware production. The same trend is now observed for Intelligent Tutoring Systems, while most Intelligent Tutoring Systems are still domain specific. However, there are very few shells, therefore the cost of development of intelligent courseware could not be dramatically reduced.

An ITS multimedia prototype has been demonstrated. It specialises in teaching procedural skills involved in applying the procedures required to use computer interfaces. In this case, the task of the author consists initially of describing elementary interface actions, linked to a screen dedicated to the program to be taught, specifying a procedural hierarchy of tasks and sub-tasks and regrouping them into higher level procedures. The author also specifies concepts associated to tasks, and defines links between these concepts and procedures. Multimedia capabilities have been added to this prototype extending its scope [AAT 3].

Learning systems development normally encompasses the following steps:

- instructional design, including learner modelling;
- domain modelling;
- authoring;
- delivery.

2.1.2.1 Instructional Modelling

There is frequent disagreement about what constitutes an "instructional strategy". Builders of Intelligent Tutoring Systems frequently use the term 'tutorial strategy' to describe the dominant characteristics which structure the intended interaction between their system and a student. These "tutorial strategies" may be closely related to theories of cognition or models of learning which are seen as essential elements of the tutoring system design. During the course of a specific tutorial, local adjustments to students' needs are made in terms of "tutorial tactics". These are based on a very fine-grained representation of the domain being tutored and a student model of greater or lesser sophistication. Attempts are often made to give the learner greater control over the interaction.

Adherents to instructional design theories generally have a different set of priorities. They may be less concerned with theories of cognition or varied modes of human-machine interaction, preferring instead to take a narrower view of what constitutes a "strategy". Their purpose is to determine theories of education which are generally applicable. In this context, the term "strategy" is more likely to refer to the step-by-step decisions which attempt to optimise the student's progress through a curriculum, with

little emphasis being put on the nature of the individual student's experience.

In summary, ITS designers are concerned with the nature of individual learning, while instructional scientists seek generalised solutions, and the argument is frequently couched in terms of a trade-off between generality and power. The search for domain-independent tutoring systems continues, along with the debate as to the merits of each approach. Though if viewed in terms of pedagogical value in an organizational context, they may be complementary options [OSIRIS 5].

The instructional design and cognitive science literature provide a wide range of analyses which can be used to derive instructional goals and strategies. This literature has been thoroughly reviewed in a way which tries to bridge the ITS/Instructional Science gap, and which draws the relevant conclusions relating some of these goals to the provision of adaptive tutoring [ACES 2]. A less comprehensive review derives a range of instructional goals from the literature, and considers how some of these may be used to design techniques for organising the domain material [MATIC 1].

Other work has taken a particular instructional design theory as a starting point, and developed it to identify sets of 'instructional transactions' which are relevant to the design of interactive educational software [SAFE 8]. This work identifies a distinction between strategies and tactics, and also considers the issue of learner control. The extent to which the resulting ideas could be used to develop tools supporting the design of educational software is also considered.

When it is approached in this way, instructional design theory may provide a generic structured conceptual model of the educational aspects of courseware which is independent of learner or domain characteristics. It is the basis for a software engineering approach which abstracts and formalises the teaching strategy modules of specific applications [SAFE 19]. Ultimately, this formalisation results in the definition of specific software packages.

From the cognitive perspective, learning results from the acquisition of a deep structure of the domain of study, in other words from the creation of mental models of the domain objects and their relations. This can be described as the iterative acquisition of production rules relating to an intertwined hierarchy of concepts (Anderson) or as the development of hierarchical conceptual trees as implemented in [AAT 1]. The learner behaviour needed by this approach is much more demanding than that required by traditional stimulus-response theory (Skinner) which led to so many failures in computer-aided learning. It is the very basis of active learning but it puts heavy demands on the learner's initiative. Consequently, powerful didactic tools have to be used such as hypertext, storyboards, agendas, simulations and ITS. The complexities involved in building or using these tools in a wide variety of teaching situations has led practitioners to seek a basic theory which can offer some guidance.

This has resulted in a "pyramid approach" used as a framework for domain-independent instructional strategies and tactics as well as for lesson structuring [SAFE 13]. This framework crosses borders between applications and establishes for the first time a useful sequential strategy as an approach to lesson planning, as well as a taxonomy of available tactics and elementary teaching transactions.

This approach owes a lot to Gagné and Briggs and analyses the available information about the learning environment, (learning situation, learner profiles, end goals), and establishes a tangled graph of intellectual goals to be reached in the given situation. Instructional strategies are then used to select and organise teaching modules which fulfil these goals. Each module is composed of elementary teaching units which detail transactions between the learner and the machine. Sets of rules lead to the selection of the most appropriate kind of modules for a given situation.

Once a module is chosen, its decomposition into elementary transactions is also specified by rules selecting from a choice of 28 transactions (eg. feedback, warning, operation, question, adjustment, demo, hint) [SAFE 16]. Although these sets of rules now have to be augmented by domain-specific rules, the most important result of this methodology is a very rapid prototyping of a lesson plan leading to huge savings in the authoring workload.

As with all formalised methodologies, strong constraints are imposed on authors as they are not free to step outside of the list of available options. The framework must therefore be extended in two ways.

Firstly, domain-specific goals, strategies, tactics and transactions must be added to the basic list available for a very differentiated application domain such as simulation-based learning. Here, at each level new concepts have to be introduced in the general methodology. New goals such as understanding the causal links between events have to be elicited by new strategies such as hypothesis generation. These strategies have then to be implemented by specific modules such as "perform an experiment". These in turn have to be implemented by specific transactions such as experimental planning, equipment preparation, result acquisition, and discussion [SAFE 19]. The very fact that all these modifications are possible within the general framework is in itself a very positive result suggesting that the framework is a genuinely useful development. Similar generalisations have been made to optimise instructional design frameworks for multimedia [CAMCE 3].

The reductionism inherent in the formal methodology is very useful for drafting lessons but is felt by many authors to limit their expressiveness. To cope with this problem, a second extension to the framework would involve the building of expert systems to implement the above approach with its modules and transaction taxonomies. If these expert systems operate incrementally, the author will be able to use powerful editors

and lesson planners to try new kinds of transactions and modules [AAT 1]. When successfully tested, these new transactions, or even module plans, could be integrated in standard libraries and their associated rules incorporated in the expert advisers. In a specific implementation for multimedia, such systems have been built to give help and information about the process of courseware development, the status of a particular project, the handling of specific tools and their inter-relationships [CAMCE 3].

Where tutoring or authoring systems have actually been implemented, they generally owe their allegiance to instructional design [TOSKA 2]. Of particular interest is a design for a tutoring system (CAPRA) based on a blackboard architecture. While this system takes an instructional designer's view of strategy, it aims at achieving the adaptability of an ITS and views tutoring as a cooperative interaction between two agents. This system attempts to achieve a degree of domain-independence by using two blackboards, one for the domain and the other for system control. At the same time the design attempts to maximise the flexibility and adaptability of the system in two ways: it maintains a student model which is used to modulate the instructional strategy, and it provides knowledge sources related to system-student conflicts and to possible errors and misconceptions. It is also worth noting from the point of view of 'method' that the actual work of design was preceded by protocol analysis research intended to determine a relevant classification of instructional activities.

One rather different approach emphasises the notion of "Instructional Expertise" [TOSKA 5]. It is claimed that an instructional process is not so much driven by a theoretically sound strategy as by knowledge and experience about instruction. Most of the competence of human teachers to flexibly deal with various and sometimes unexpected teaching situations is due to their possibility to use their instructional knowledge and experience.

This work starts from the assumption that, to a large extent, this Instructional Expertise can be described generically, i.e. not depending on a specific teaching situation or a subject matter. If this is correct, it would imply that both the development of ITS' and the dynamics could be supported by a generic instructional knowledge base.

Most of the work has been concerned with validating this non-straightforward assumption. Based on a Components of Expertise metaphor, a framework for capturing Instructional Expertise has been developed (GTE). From there, a prototype GTE implementation has been built and demonstrated. With this prototype, a few distinct areas in the broad domain of instructional knowledge have been modeled and applied to various different domains [TOSKA 6].

In conclusion, we can say that considerable progress has been made in producing a synthesis of cognitive and instructional design theories, and in applying this to the various design disciplines of educational computing.

2.1.2.2 Learner modelling

While implementation within Computer-Based Learning remains a serious problem, a number of learner modelling techniques have been developed. They are often complementary since they address different parts of a framework based upon the computational distinction between, in one dimension, behaviour, behavioural knowledge and conceptual knowledge, and, in another dimension, the system, the learner and the system's representation of the learner [NAT*LAB 1 and OSIRIS 5].

Some knowledge-based learner models are founded on declarative knowledge representation while more complex ones make use of generative systems. Both approaches allow subset modelling (overlay) and perturbation (buggy) modelling. Models are used to dynamically build the dialogue or to guide the user in a learner driven dialogue.

Elementary Learner Model

One may consider that the construction of generic systems is premature, thus enabling the provision of domain-independent methods across all domains. Declarative knowledge representation may be used as an intermediate solution between traditional Computer-Based Learning and Intelligent Tutoring System researches.

Viewing the learner as some variation of the expert is behind the state of the art but allows easy implementation within a particular domain. To automate this process, student modelling toolkits are proposed as an alternative strategy to more complex A.I. based models [ESM-BASE 5].

The structure of the modelling, based on the granularity of the domain, makes it easy to assist the delivery of learning material organised in ULMs. Besides the domain itself, the model is sophisticated enough to incorporate learner's misconceptions. Unfortunately this model was essentially based on a Boolean view and is now obsolete as it was unable to effectively manage learner's preferred topics and learning styles; it did not support the fuzzy and progressive reality of the learning process and is therefore unable to deal with the dynamic of the dialogue.

An important consideration is that even elementary learner models, based on declarative knowledge representation, are powerful enough to demonstrate the feasibility of a modular approach of the courseware and to prove the consistency of dialogues founded on an atomic structure of elements. Modularity dramatically improves the efficiency of courseware production.

Knowledge-based Model

The overlay model was suggested in the early stages of Intelligent Tutoring System. However, the current state of the art has rejected this model as it ignores most parts of the learner's own curriculum.

Better models have now been designed and, as opposed to expert knowledge, these models include perturbations which reflect, inter alia, learner's misconceptions. As these models are more complex, they are less common and may present significant problems in the areas of elicitation and articulation. Models may include a reference to preferred learning styles.

Some research work concerned a principled design methodology for this kind of model based on the concept of "inverted dialogues". This methodology consists of a number of phases: it starts with the incorrect performance of a real student; the second step is to try to understand the error or misconception; the third step is to test the correctness of the expert's understanding of the error; finally, the fourth step is the required formulation of the understanding. The techniques used for understanding the student's errors and checking the understanding of the expert are based on role-switching, in which both the system and the expert are asked to simulate the behaviour of the student. In this context, a survey of possibilities for applying Machine Learning techniques has also been carried out.

Few learner models are concerned with long-term learner characteristics documented in the existing literature, including motivation, cognitive style and focus of control. So-called "static attributes" are interesting because of their ability to support dynamic decision making. Proposals also address controversial issues on a possible identification of "types of learners" [TOSKA 3].

Basic research on emerging technologies

Even with today's decreasing costs, hardware and software solutions for educational systems must realise a difficult compromise: the number of end-users points toward low-cost solutions but, on the other hand, many essential requirements may only be met by using advanced tools, sometimes still at the research level. It should indeed be realised that many problems encountered by ITS stem from the fact that building an intelligent tutor is probably more ill-defined and more difficult than most other tasks undertaken by the Artificial Intelligence community.

In this context, feasibility studies were carried out and work was done to identify promising trends of basic research and to estimate the cost effectiveness of these solutions for a time horizon of five years.

Designing expert systems for learner modelling and instructional strategy is usually confronted with what has been termed "the knowledge acquisition bottle-neck":

- how to extract knowledge on teaching strategies and learner modelling from the expert teacher?
- how to express these ill-defined concepts in the somewhat rigid formalisms of expert systems.

Neural networks learn from examples and cope with slight extensions or fuzzy task modifications. Their use to solve the bottle-neck problem was therefore investigated: can they be used to synthesize automatically learner modelling and teaching modules from examples [NAT*LAB 2].

It was shown that this technology has a clear potential: in one application, a neural network was given examples of sequential reasoning done by an expert and learned forward and backward strategies for solving electricity problems. Once having mastered strategies, the network was then used as a basis for a flexible tutoring module. The same network, using examples from beginners, developed imperfect strategies. Comparisons between the tutor and student modules provided a basis for fuzzy learner modelling. Being non-symbolic, neural networks are not very well adapted to the design of explanatory modules. Therefore, a related methodology (classifier systems and generic algorithms) which simulates natural evolution and selection of production rules was also tested.

Neural networks, classifier systems as well as many other advanced methodologies (ITS, simulation) are hungry users of computing power. All these tasks however have an intrinsic parallelism. Classically, parallel computers have been too expensive to be considered in the educational field. Recently, however, cheap parallel hardware extensions and programming systems have appeared. Their use in advanced education systems was examined. They provided important increases in performance and their use was judged to be a critical success factor for using the advanced methods discussed here [NAT*LAB 3].

However these preliminary studies do not allow for a final conclusion to be drawn on the potential and the cost-effectiveness that could be reasonably expected from the parallel and connectionist approaches in the next few years.

2.1.2.3 Domain Modelling

A domain is an area of knowledge and skills which contains all that has to be learned in relation to a particular subject. Systems which are designed to reason about either authoring or tutoring need to operate on an abstract representation which describes the relevant domain in a structured way. In different cases, this representation has to

serve the differing needs of author, student, authoring system, and tutoring system. The process of producing this representation is known as domain modelling. Intelligent Tutoring Systems frequently try to gain as much power as possible by exploiting the structure of the domain being taught, and by reasoning about specific representations of that domain. Authoring systems generally move in the opposite direction, and try to find terms of description which are domain-independent, so that the system may be used by a variety of authors in a variety of domains. While remaining general, the terms of description must also allow authors to describe educational interactions which they (and ultimately the students) consider to be meaningful.

Domain modeling is thus a complex issue which is seldom dealt with at a detailed level until a project reaches the implementation stage. Where systems concentrate on a single domain, as is usual for ITS', the issue generally arises very early in the development process. For authoring and authoring support systems, detailed specifications of domain representations tend to be produced later in the development process. The available deliverables describe no domain-specific ITS', and those authoring systems which are described concentrate on analyses of instructional skills. For this reason, there are relatively few complete analyses of domain characteristics.

A global description of the domain modelling process is described in figure 2.5. Resulting products are indicated by white boxes, external factors by black boxes, processes by ellipses and methods and tools by shaded boxes.

There are, however, some useful specifications and partial descriptions available. The specifications [TOSKA 1] describe structures which may be used for the analysis of multiple domains. These consist of 'topics'. Topics can be 'compound', where they are composed of sub-topics, or 'primitive' where they are not sub-divided but are directly related to elements of courseware. Figure 2.6 gives an example of such a domain. In this diagram, modules are small pieces of courseware which can support a learning activity with a small set of learning objectives; basically the link from a module to a topic might be termed as IS-USED-TO-LEARN-ABOUT.

The elements of courseware, or 'modules', are structured by a variety of links and attributes which are intended to express conventional pedagogical wisdoms, especially those of Merrill. The concept of a module is designed to mask the implementation detail of the courseware, ie. the nature of the instructional material, so that the system may reason in general terms about such modules. A series of steps utilising these structures for carrying out the domain analysis and modelling is also described. These steps identify the salient features of the domain, assign appropriate links and attributes, and illustrate common misconceptions.

While the generality of this analysis looks promising, a demonstration of its usefulness in a fully-implemented system has yet to be accomplished.

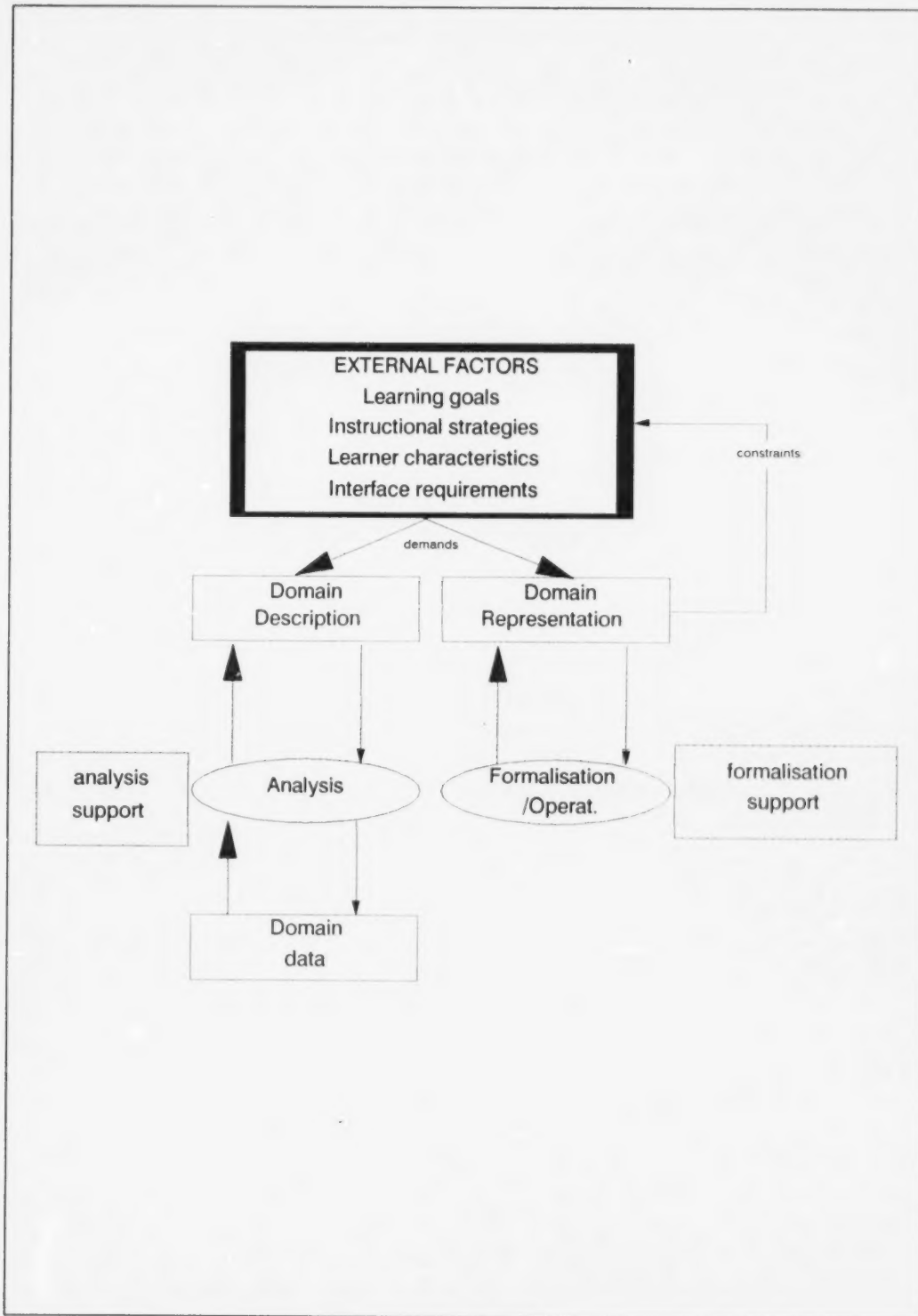


Figure 2.5: Conceptual framework for domain modelling [SAFE 26]

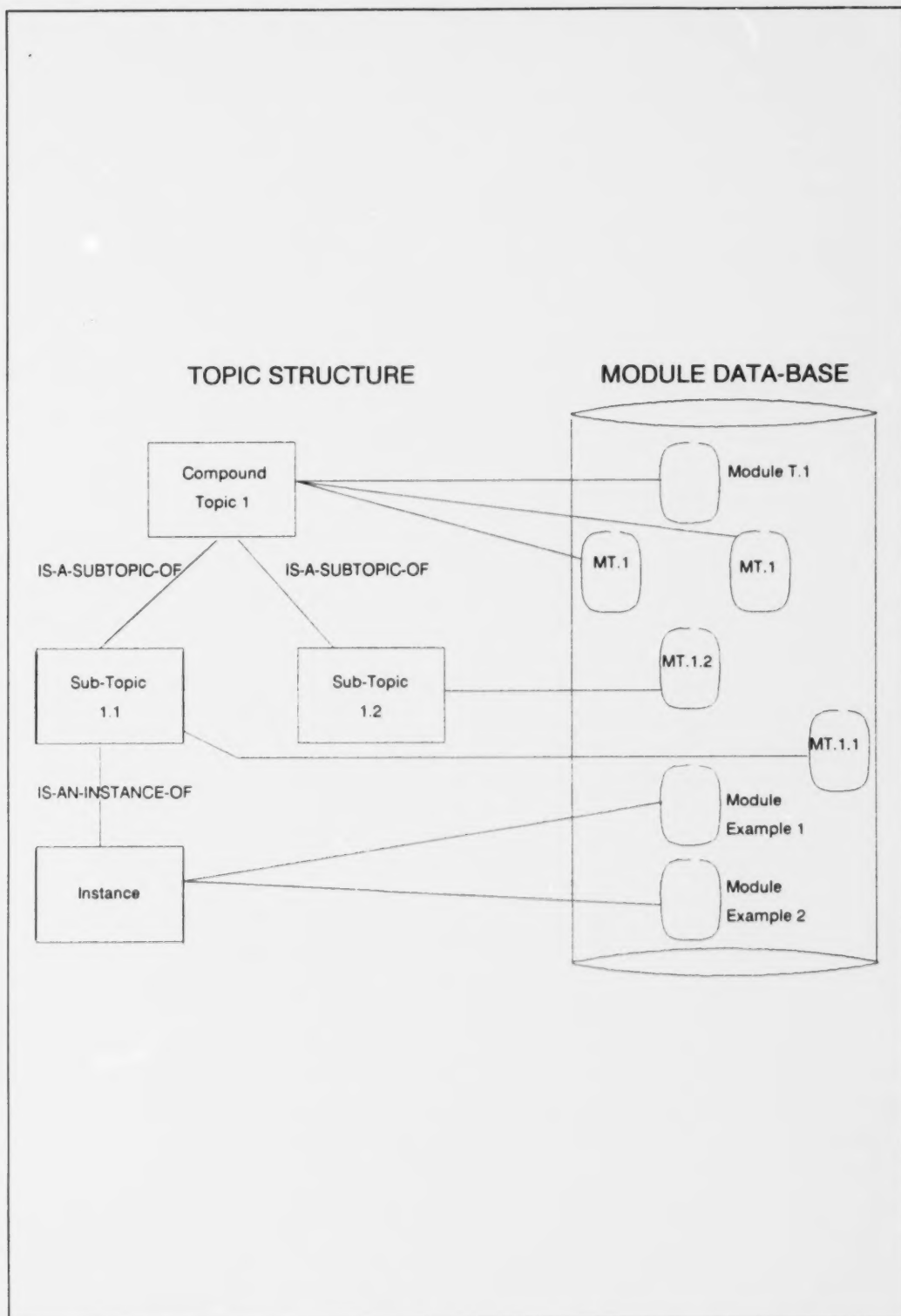


Figure 2.6: Example features of a TOSKA domain [TOSKA 1]

Several descriptions have been made of individual domains [NAT*LAB 1]. One uses a constraint-based formalism to express a linguistic grammar for second language learning. Consideration is given to how such a grammar could be used in a tutoring system. A related project describes a tool for acquiring knowledge from expert teachers regarding pedagogical and grammatical information related to students' mistakes in second language learning. This information is represented in a frame-based formalism which encodes varying explanations of the mistake and comments upon it. A system architecture designed to exploit these representations of the domain is also outlined.

A current issue of debate among ITS designers concerns the question of whether or not a single representation of the domain is in any case adequate to support flexible and successful tutoring. It has been suggested that multiple viewpoints on each domain are necessary for a variety of reasons [NAT*LAB 1]. The techniques used to represent multiple viewpoints for systems in the past are reviewed and a range of technical problems defined.

Therefore, it may be concluded that much has been achieved in clarifying the issues and problems related to domain modelling, in spite of the lack of fully-implemented systems.

Knowledge Support Tools

In an Object-Oriented approach, all the entities involved in the courseware development process are considered "objects" having various properties and relations. All the activities of courseware development are then viewed as networks of objects (data structures) and methods (software tools acting on data structures).

The implementation of this approach may be built on two main layers: an object oriented model and a multimedia object management system. In this architecture, the object oriented model is responsible for the managing of working environments, for running methods on data structures and for managing abstract levels. On the other hand, a distributed object management system allows the manipulation of the objects and their relationships, ensuring, in a network of workstations, the transparency of the sharing of the object base [CAMCE 10].

Within an intelligent authoring tool, the domain analysis is an important task which, however, does not consider how things should be taught or learned, i.e. media and methods. First of all, the components of a domain (topics) must be identified. Merrill's distinction between three kinds of components is considered, so that topics belong to "compound topics" (having content and an internal structure and described through their relationships with sub-topics), "primitive topics" (no internal structure) and "structuring topics" (no content, internal structure only). Beside topics, a set of modules, to be attached to topics, is built to support learning activities [TOSKA 1].

On the other hand, the representation of teaching expertise, and its possible embedding in the courseware, is fundamental to the production of intelligent courseware; this process has dramatic consequences on the re-usability of the courseware methodology.

A distinction must be made between "instructional tasks" (building blocks embodying all recognizable activities of a tutor, at all levels of detail), "instructional method" (Knowledge-based representation of a mechanism to realise a particular instructional task) and "instructional primitives" (objects filled-in with content coming from the domain) [TOSKA 2].

Knowledge-based Adviser

For large courseware development projects, a need may arise to guide users through the collaborative process in a distributed environment. Users need explicit help and information about the process of courseware development in general, about the status of the project, about specific tools and facilities and about the interrelationships among these items. A Knowledge-based adviser has to be designed to solve the orientation problem. It should be noted that, in this case, the adviser must be considered as a help to authors but not as a sub-system managing, within the courseware itself, learning strategies or domain-oriented knowledge and skills: the core of the adviser is the conceptualisation of the application domain by means of representational structures and problem-solving methods; the application domain is courseware development [CAMCE 3].

2.1.2.4 Production of Learning Material

Editing learning material

Authors are involved in creating multimedia units and combining them into larger units that can be turned into units of learning material. As multiple media (text, image, sound, etc) are used, several editing tools must be integrated, providing the user with a consistent interface. In fact, the editing is achieved within a continuum of author-system communication, which allows the combination of visual programming, assembly of pre-defined procedures and direct programming in Pascal or C [AAT 3]. Figure 2.7. describes the potential components of a multimedia scene.

Structuring the learning material

Units of learning material (ULM), created or assembled by mean of editors, must be organised to decide on the presentation order (traditional Computer-Based Teaching) or must be linked to concepts in the learning domain (intelligent systems). In the latter approach, the system will then decide on the presentation order [AAT 3].

The definition of ULM is a critical issue which deeply affects the usability of a database

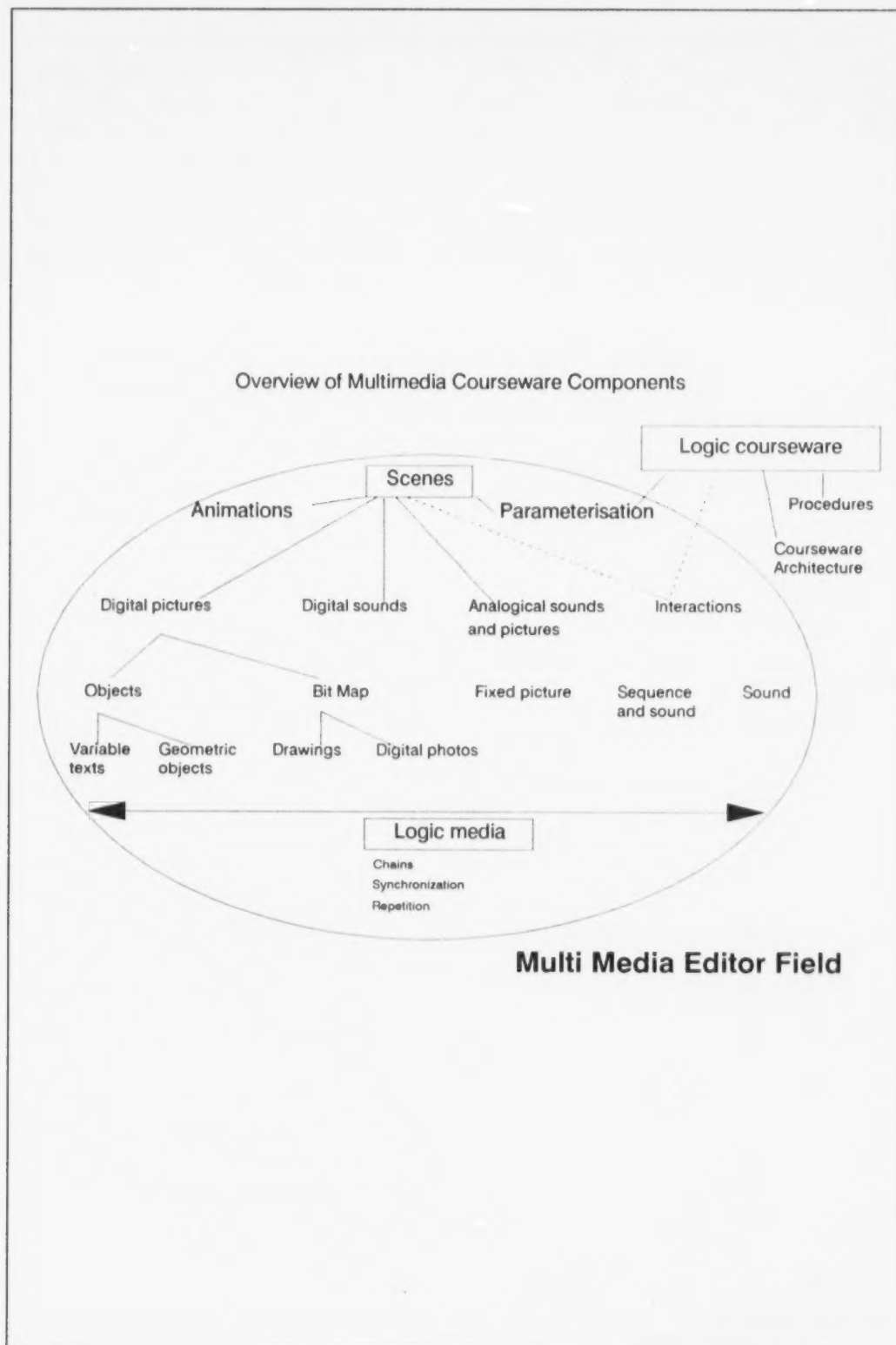


Figure 2.7: Multi Media Editor Field [AAT 1]

of learning material (DBLM). The research tried to identify a suitable data structure that would allow many different views of the same database. The current conceptual scheme associates a ULM to educational functions, topics and structure in a many-to-many manner (figure 2.8). This approach allows the usage of a DBLM as a resource for the author who is building a new course or for the student who wishes to browse; the educational material can also be used directly by an intelligent tutoring system implementing a specific teaching strategy.

2.1.2.5 Delivery

The term "delivery" is used here to refer to the phases of the learning process involving any kind of interaction with the learner. The cognitive processes embedded in these interactions are managed by learner modelling.

Several approaches are well-known to understand and/or organise the learning process, principally the approaches of Merrill [SAFE 8] and Gagné & Briggs [ESSENTIAL 7].

Control by the Learner

Learner control is the opportunity offered to learners to assess their own progress, to compare their evaluation with the system's values. Furthermore, learner control will improve the quality of the learner model since values issued by the learner (self-reported) are incorporated into the model [AAT 3 and 4].

Learner control also enables the learners to comment on the content of courseware and incorporate their comments in the data [SAFE 2].

2.1.3. Simulation techniques

Dynamic systems (electrical and mechanical networks, biological or economical systems) play an ever increasing role in science and technology and present many educational challenges. To understand the behaviour of dynamic systems, learners need a hands-on approach which, in many cases, is best done using simulation.

Qualitative jumps in didactic effectiveness are expected if simulation of dynamic systems becomes widely available. Simulation systems should be coupled to multimedia [AAT 2] to maintain contact with reality. Hypermedia should also be used to link the model to higher-level educational material [SAFE 9] and to training management systems, in order to meet the needs of different institutions or companies. A recent survey in the Netherlands [SAFE 1] showed that more than 50% of the courseware used in there had some embedded simulation.

However, it is not sufficient to give learners a computerised model and a friendly interface. To really get a deep insight, the learner must, at the same time, use a complex

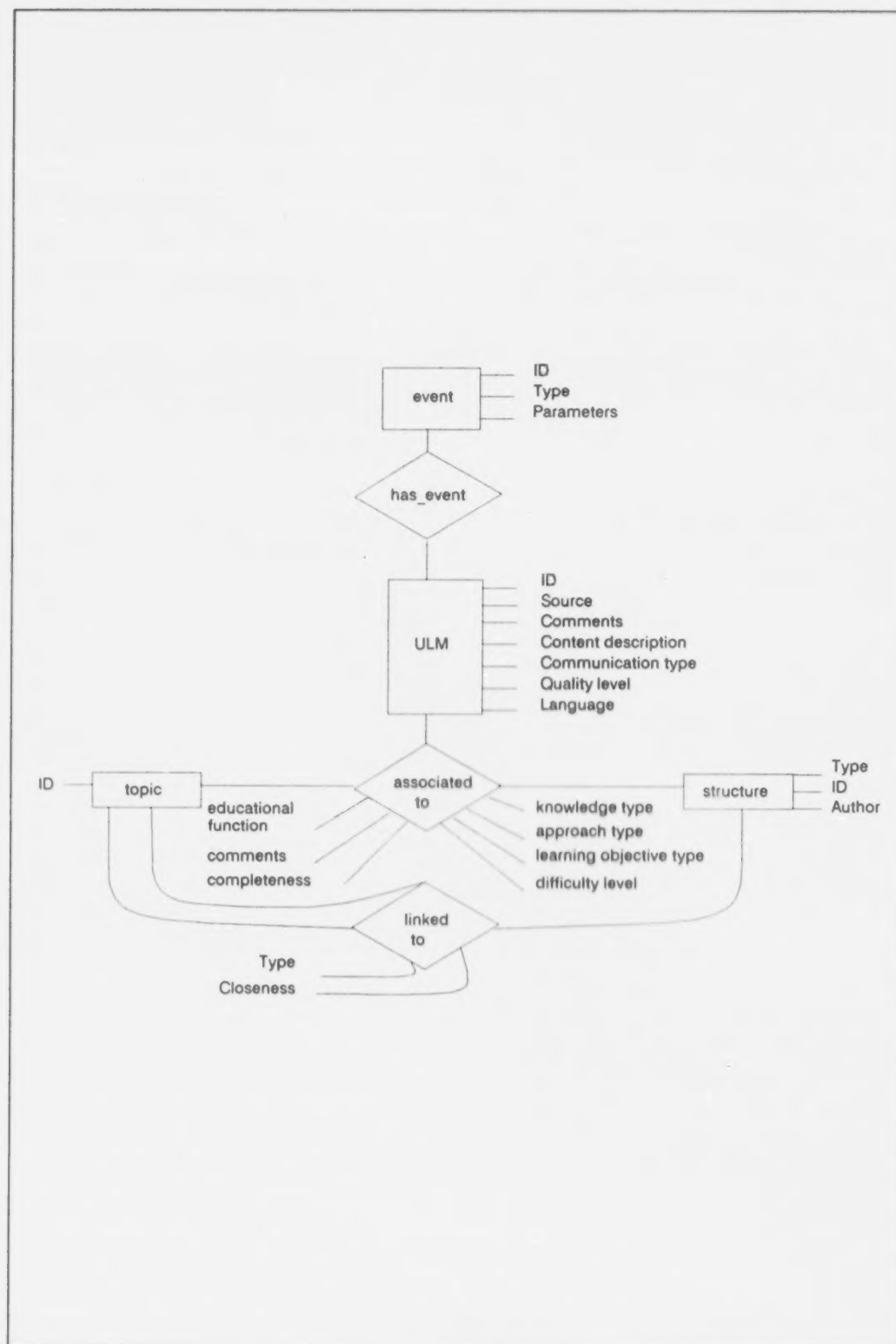


Figure 2.8: Conceptual schema for a DBLM [ESMBASE 1]

technical tool. This complex learning situation may be seen as the creation in the learner of a conceptual model-related map. These mental maps have obvious similarities with the activated conceptual space idea frequently advocated in instructional strategies [AAT 2]. However, they are in need of supplementary, temporal and causal mechanisms similar to those found in qualitative simulations. Such high-level intellectual constructs are nearly impossible to transmit through simulation or classical courseware and are best managed if an instructor provides support (both directive and non-directive) and monitors students' activities. In the context of computer-aided learning, this translates into the need for an ITS adapted to simulation.

In the context of Open Systems for Instructional Development (OSID), special attention was paid to the functional architecture of intelligent simulation learning environments (ISLE) [SAFE 21] in a special task called **SIMULATE**. This ISLE concept has never previously been explored in a generic way and will probably be at the very basis of future work in educational simulation authoring systems.

The functional architecture of the ISLE shell consists of 4 top-level, functional, inter-related blocks: the Learner Interface Manager (LIM), the Learner Model Manager (LMM), the Instructional Support Manager (ISM) and the Runnable Model Manager (RMM). Figure 2.9. depicts the run-time of the ISLE shell in terms of data flow.

The goals of **SIMULATE** were the following:

- to develop a conceptual framework for exploratory learning of dynamic systems through simulation and to list the learning processes, learner attributes and teaching strategies involved;
- to develop the definition of the functional architecture of an ISLE and of the corresponding authoring tools environments;
- to formalise the different components of this ISLE and to define an initial authoring tool set for ISLE, as an instantiation of the general OSID concept and, particularly, of its re-usability concept.

Due to the novelty of the field, the results are expected to be of an **exploratory nature**. The main output of the project [SAFE 1] is the first complete study available in the field of learner needs and characteristics, psychological processes and teaching strategies in reference to educational simulation [SAFE 23]. It should therefore become a reference for future authors of ISLE systems.

This survey starts from a description of four main themes which must be present in every ISLE: nature of formalised manipulable models, learning goals, elicitation of specific learning processes and presence of learner activities [SAFE 22]. It then describes how the main classical components of an ITS (domain module, learner modell-

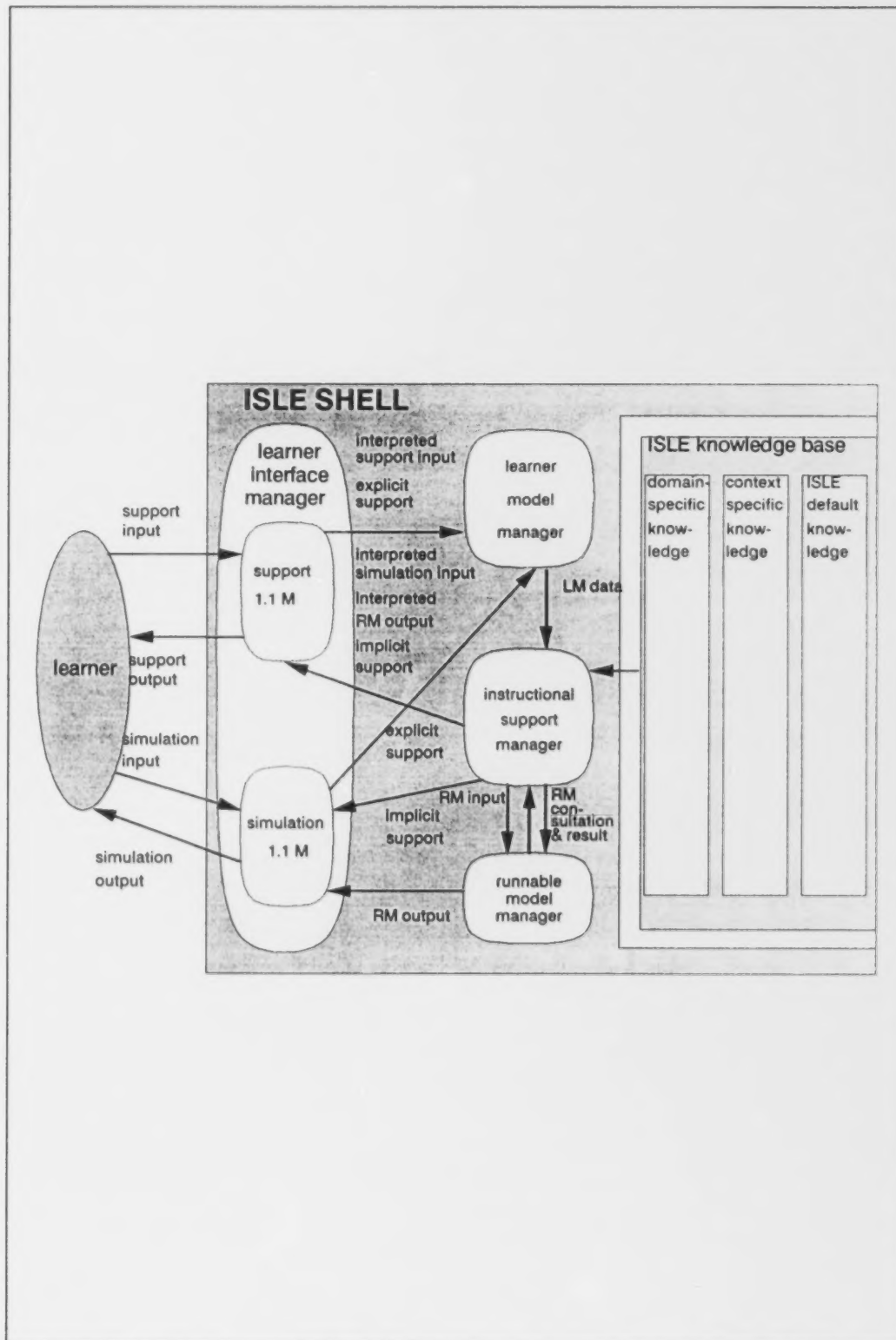


Figure 2.9: The ISLE functional architecture [SAFE 24]

ing module, teaching module and learning interface module) should be adapted to these four themes.

A companion study [SAFE 7] made an inventory of the tools available to implement the four previous modules. Its most useful result was a list of problems encountered by learners when dealing with simulation. This is essential since most failures in the field have been due to insufficient efforts being devoted to the observation of real users. This list is a basis for any planning of user-modelling tools in simulation environments. The main conclusion of the deliverable is important for future work: due to the overwhelming complexity of the issues, there is more reward in developing tools (planners, scratch pads, intelligent help, expert system shells) which may be adapted by authors to the needs of an application and then used by learners, than in trying to develop generic learner modelling and teaching modules. After these studies, a functional architecture for an ISLE has been published [SAFE 24] and it provides the required starting point for software engineering of ISLE-type systems.

A formalisation of the main concepts, modules and user-interfaces using an intermediate pseudocode, between high-level descriptions and low-level programming, was also produced [SAFE 19]. This is similar to the SAFE OSID half fabricate concept [SAFE 10] or to the concept of primitives in open learning material developed in the LEAST project [LEAST 4]. The SAFE document is a first impressive step towards formalising learner and instructional support modules, authoring support and user interface tools. Such half fabricates are essential to large-scale projects and should be looked at by designers concerned with similar issues in other kinds of ITS.

The SAFE/SIMULATE theoretical approach is usefully complemented with a more pragmatic approach [AAT 2] in which multimedia editors and software libraries have been used to build special purpose, high-quality visual simulation interfaces. In addition, coupling this system with an intelligent tutoring system has been implemented and is actually functioning. Pilot testing of most of the SAFE semi-formalised concepts should be feasible with minor extension of the AAT system. In the future, the combination of these top-down and bottom-up approaches should provide highly valuable feedback.

2.1.4. Hyper/multi media

2.1.4.1 Data representation and databases

A clear description of the requirements of the learner and author allows the functionality of the database to be specified. These databases are likely to be much larger than those envisaged in sections 2.2.3 and 2.2.4, typically occupying a 650 Mb CD [SAFE 12]. An analysis of the taxonomy of multimedia databases, hierarchical, network, relational,

object-oriented, semantic, hypermedia, or knowledge-representation systems [SAFE 15], concludes that the first three are too inflexible, that AI-based systems are too domain-specific, and that the best options are augmented data models such as hypermedia. Consequently, a paradigm shift may be required in the way users interact with information bases, away from ambiguity-free query- definition towards 'close-enough' results and subsequent manual modifications of the results table.

The current interest in Object Oriented (OO) methods has clear relevance to hypermedia and a number of OO approaches have been adopted. A conceptual model was created of an OO multimedia and an ObMachine data manipulation language. The ObMachine primitives are Prolog clauses supporting a semantic net representation. A wide review of OO system prototypes identified:

- features which were not adequate to meet the requirements of new applications, such as all data stored as relations;
- the real-time requirements of advanced data systems, such as support for objects of variable structure, or for large storage objects;
- the inefficiency of tree-structured data, and of limited type constructors [CAMCE 4; see also section 2.2.3].

Similarly, objects and programmes are treated differently in a relational DBMS, but they are both treated as database objects in an OO DBMS, with consequent gains in efficiency [SAFE 4].

A complete formal specification of a hypermedia data model and OO DBMS has been built to meet the requirements of the learner interface, which is compatible with emerging international standards and offering wider applications. It defines items (nodes) and links, and views (of the database) as objects. The OO DBMS was built as a demonstrator in C + +. The class Item has data variables Description (text), ContentType, Properties (attribute-value pairs), Anchored Links etc. The class Link has data variables Source, Target, Type, Weight. The class View has data variables Name, Password, Description, CriteriaList. It has been implemented as a demonstrator [SAFE 4 and 11] for multimedia link attributes, see also [AAT 2].

The Hypermedia Query Language, HyQL, was designed to facilitate access to the information within the hyperbase. Use of HyQL results in C + + triggering the methods associated with the objects to produce a list of the same. The as yet undefined hypermedia engine will communicate with the database by means of HyQL, but HyQL will also be embedded in the user interface. A prototype tool for extracting database information from SGML encoded documents was also built [SAFE 4].

A reference model has been created as the basis for standardising technological aspects of learning systems. Protocols for networked interactive multimedia applications were described, based on the activities of three agents, including those for program execution and user interface presentation. Encoding in ODA was considered as a standard for source documents but it is content-oriented and not interactive. Audio-visual applications are state-oriented, and hypermedia are both state- and data-oriented as well as interactive, implying that the standards would require some revision to be acceptable for hypermedia. The proposed standard courseware-interchange format is partly based on the description of ASN.1 (Abstract Syntax Notation One) - also used for the interchange format of ODA [LEAST 3].

Authoring for hypermedia

The authoring process may be divided between the activities of "first author", responsible for identifying writers and sources of existing material, and "second authors" who convert the material to hypermedia format. The "first author's" task is similar to that performed in the publishing industry, where many texts are encoded, eg. in SGML which, as has been demonstrated, may be translated directly into hypermedia. The second author operates at two levels, editing material into a form suitable for screen use, and introducing the hypermedia links, which are similar to the cross-references found in text-books. In the context of the large hypermedia databases envisaged, the linking task is far too large to be performed manually, and automated methods must be used. Procedures from graph theory may expedite this task. The structure supplied by graph theory may also support the user's navigation task, eg. by providing representations of the centrality of concepts. A tool-oriented analysis of the authoring process has isolated 14 steps from determining sources of information to production of the finished hypermedia, most of which require unique multimedia editors and databases, and tools for knowledge mapping, most of which do not yet exist, although some are similar to the multimedia editors for units of learning material [SAFE 6, ESM-BASE 4].

2.1.5. Learner interfaces

Extensive research has been carried out to determine what kind of interface is required for Curriculum Support systems and Educational Multimedia Database systems. The methodology used in these projects usually defines the requirements of the various categories of users and the tasks they need to perform. A functional specification of available interface is then developed. The need to adapt to user requirements implies that the user must either be able to choose the interface required, or that the system must maintain some model of the user which determines what interface is currently appropriate.

In the NAT*LAB project [NAT*LAB 5], a comprehensive study of user-interface design and design tools was carried out, with particular reference to user interfaces for intelligent tutoring systems. The assessment of user interfaces was based on a communication model of how meanings and concepts - rather than simply actions - can be conveyed between the ITS and the user. The study covered not only the different styles of interfaces and UIDS' available but also addressed existing guidelines for designing interfaces. Whilst most current design guidelines are at the syntactic level - i.e. the appearance and behaviour of an interface - the study concentrated on assessing higher-level guidelines and summarising them in terms of their relevance to intelligent tutoring and knowledge-based systems.

In an Intelligent Tutoring System, the model of the user is generally referred to as a "student model" or a "learner model". Comprehensive reviews of techniques for student modelling have been produced and related to the tasks of courseware design. [TOSKA 3]. The nature of the model, and thus of the interface adaptations required, depends crucially on the domain representations and educational strategies used. Where a system has a more general function, designers refer to "user models". Techniques for user-modelling have been reviewed, [ACES 4], as preparation for the design of a Curricula Support System. In this design the model maintains information about the current tasks and characteristics of the user which is used by an "interaction manager" to provide the appropriate interface. Tasks deemed appropriate to such a system include both courseware selection and courseware delivery and potential users are seen as learners, tutors, authors and curriculum designers. Viewpoints appropriate to each user must be provided by means of the interface [ACES 5].

In order to deal with this complexity, the design approach makes a clear distinction between conceptual models of the relevant tasks from the perspective of a) the user and b) the system. The users must be helped in formulating their goals, and the system must "understand" what is expected in relation to them. This means that different functionalities of the system must be made "transparent" to the current user in each case, i.e. the interface must express a suitable conceptual model, and that the system

must be able to carry out the required activities in relation to it.

Elsewhere, a system which follows the alternative approach of allowing the user to choose the interface which is required has been implemented [ESM-BASE 5]. This was intended as an interface to an Educational Multimedia Database. The different materials available and different possible goals relevant when interacting with the materials mean that a range of interaction tools must be provided. These would, for instance, allow the user to either browse through the database, or run a specific piece of video backwards and forwards. In line with the 'direct manipulation' philosophy of using a real-world metaphor to structure the user's interaction with the machine, the different tools are represented as "tabs" on a set of office files.

In addition to the use of specific training material (courseware, simulations and hypermedia), some generic "learner tools" are likely to be extensively used in the near future, such as notebook, dictionaries, calculator and terminal emulator, etc. It is of paramount importance to the user's acceptance that all applications, tools and courses be held on a coherent user interface [EPOS 17].

2.1.5.1 Simulation learner interfaces

Due to their dynamic aspects (cf. section 2.1.5), user interfaces for educational simulation present problems. These problems have been tackled in [SAFE 19, AAT 2].

The success of a simulation is critically dependent on its interface, which directly mediates many didactic interactions using animations, graphs, control panels, explanations, lesson planning etc. However, like most human-machine issues, interface design is still more of an art than a science and trial and error is still the most appropriate method.

In the past, this problem has always been solved on a case by case basis, which usually takes up more than 80% of the project-time [CAMCE 4]. Identifying the need for a more structured approach, SIMULATE starts from a classical software engineering definition of a user interface (UI) management system made up of four components [SAFE 18], which are:

- A run time UI-management system mediating the interaction between the user and the application.
- A UI-toolkit consisting of a library of procedures which invoke interaction techniques and interface components.
- A UI-construction environment in which the author uses the toolkit to draft the run-time system.

- A UI-prototyping platform dedicated to iterative prototyping with simulated functionality.

Each of these components is then adapted to the specific needs of a given simulation interface.

In the run time UI system, dynamic features are taken into account and the problems of computing speed and accuracy are predominant. In the UI toolkit, extensions are needed to customise libraries for specific simulations. These extensions define such objects as buttons, gauges, meters, switches and dynamic objects. An extensive toolkit is thus effectively mandatory.

In the UI construction environment, tools are needed to specify high-level interface components. These may be such things as a scratchpad for hypothesis generation during a simulation experiment, an interface for explanations generated by an expert system, an agenda for experimental planning or a display of instructional goals and dialogue for teaching strategies [SAFE 22].

In the UI prototyping system, a critical success factor is the availability of a dynamic animation capability. Indeed, the interface response time is critical. Tests must include not only procedural and static aspects but also a thorough study of the animation features.

This top-down approach is usefully complemented by a pragmatic approach using libraries and development editors designed for multimedia courseware to create easily modifiable prototypes of simulation interfaces [AAT 2]. It is then possible to prototype and test most of the above functionalities.

In summary, these studies have demonstrated the following points:

- In the long run, the only viable approach is to design a simulation-oriented user interface management system.
- Simulation being dynamic, interface designers must be predominantly concerned with dynamic animations. Prototyping cannot be static.
- Links between simulation and reality are essential. They are created by multimedia links.
- As simulation is a semantically rich medium, many aspects of the interface must deal not with simulation issues but with learning processes and strategies used in simulation learning environments.

As interface design is still an art, a similar iterative user-interface design methodology was used in a more general setting [CAMCE 6]. This resulted in a very fast cycle between the initial idea, designing, prototyping, testing and modifying. In addition, the need for an interface customiser was strongly felt. This customiser is a module allowing the learner to modify major aspects such as the level of dialogue, the interface or a macro-command editor for frequently used sequences of interactions, as well as in minor ones such as colour or window size. The design also uses the concept of a "virtual terminal" which takes portability issues into account. In this case, the goals were realised by using the toolkits which came with standard graphical user interfaces.

2.1.5.2 Hypermedia learner interface

Learning from hypermedia is justified by reference to the similarity of hypermedia data structures to those employed in web teaching. Hypermedia may support both explicit learning activities, such as locating information in a database, and implicit learning during execution of a task which may involve the learner annotating, adding to or modifying parts of the database. This is possible because of the essentially simple structure of hypermedia in comparison with conventional computer-based learning materials. Learner control and intrinsic motivation are considered assets of the hypermedia learning environment [SAFE 5].

The well-known problems of navigating through hypermedia data present additional difficulties for the learner, who will be unfamiliar with the material. The cognitive aspects of learning from hypermedia have been analysed [SAFE 5], as has the nature of graphical interaction [AAT 1]. Existing navigational support tools have been evaluated to form the basis of a description of the learner interface. A demonstrator incorporating certain of these navigating facilities has been constructed [SAFE 17] and evaluated [SAFE 3] to both test the effectiveness of the tools and to establish effective evaluation criteria.

2.1.6. Re-usability of learning material

2.1.6.1 Introduction

There is general concern about reducing the costs of courseware production and improving the cost-effectiveness of Advanced Learning Technology (see section 1). The investment in developing learning material represents a large proportion of total costs. One clear way to reduce development costs is to be able to re-use material created for one application in several others.

The re-usability concept is not limited to the learning material; it could cover several other aspects of courseware, design and production such as instructional design and domain modelling. This raises the issue of the definition of an independent, reusable

context Unit of Learning Material (ULM).

There is no general agreement on the size and the structure of a ULM except in the necessity to separate the instructional presentation from the instructional dialogue [EPOS 16].

2.1.6.2 The open system approach to re-usability

The Open System for Instructional Development (OSID) is a general approach to promoting the re-usability of learning material. OSID supports several objectives:

- reduction in complexity and costs of learning material development;
- increase in the quality of learning materials;
- integrated use of different learning material development tools;
- re-use of half-products and of end-products of learning material development;
- exchange of information between separate development teams and the management of such exchange.

In attaining these objectives, OSID concentrated on learning material development tools, their cooperability, their ability to manage the development process, and the ability to re-use half-fabricates produced during development [SAFE 21]. Preliminary standards for user interfaces have been described, particularly for learning material developers - where the issue of re-usability both starts and ends, ultimately for the learner as well. Support for learning material development teams at a high level involves the use of meta-tools, whereas at a low level, it comes through single tools [SAFE 25].

In keeping with this division, half-fabricates mediate the exchange of information between tools. There are three areas to be taken into account: semantics, logical structure and the physical ability of tools to read/process other tools' output. Of these three areas, the latter has been the most successful in practice. The half-fabricates (or deliverables) may be typed according to their content which in general will be multimedia, including software.

Within OSID there will be a central database, the Common Information Repository, which will support:

- information integration between tools;
- re-usability of half-fabricates;

- information exchange between development teams [SAFE 10].

2.1.6.3 The multimedia approach to re-usability

There is another, complementary approach to re-usability which operates at the lowest level of ULMs. These are very similar in principle to the units of information which exist in some multimedia databases, both relational [ESM-BASE 1] and object-oriented [SAFE 4].

In much the same way in which tools create actual learning materials in OSID, so ULMs are "glued" into a composite learning sequence [ESM-BASE 1]. In [CAPTIVE 1], a similar approach is used with respect to the re-use of segments of audio-visual material produced for interactive video. To facilitate such re-use, a database of audio-visual segments has been set up in the field of the prevention of heart diseases.

However, it is more important to appreciate the general principle that multimedia databases act as resource materials for a wide variety of applications, partly because of their large size and partly because their level of organisation may be quite fragmentary compared with the tool-based approach. This level of organisation provides more flexibility and, consequently, greater re-usability at the expense of more effort having to be put into identifying appropriate units from the database for a particular application. For this purpose, expert systems technology may be appropriate.

Some progress has been made towards this objective with SHIVA (figure 2.3), where a separate editor allows the author to specify links on the basis of concepts to be taught, or intended learning outcomes. Further work in this direction has proceeded with DOMINIE II [AAT 1 and AAT 3]. Such outcomes demonstrate a move towards a common approach to re-usability with multimedia because these latter projects were not specifically oriented towards re-usability.

2.1.7. Other productivity tools and methodologies

This section is concerned with high level tools which may be used to structure the creation of learning materials.

A courseware design methodology more sophisticated than that used with simple courseware is required to build complex simulations or information retrieval systems. As with software engineering, a structured approach to design will undoubtedly be beneficial in achieving quality assurance with learning materials. Instructional modelling, defined as the design and engineering of the didactic characteristics of educational software products, is a means of achieving this objective.

One of the most important principles of software engineering is the separation of design decisions. To identify each such decision, a framework for courseware design is required. A matrix interrelating abstraction levels and design aspects forms the framework within which design may be discussed. Four abstraction levels are distinguished:

- object system modelling, the educational organisation;
- educational design, the conceptual analysis of the educational processes;
- functional design, the software architecture;
- technical design, the software implementation.

There are five design aspects:

- goals of the system;
- functionality;
- entity structure;
- interaction;
- realisation considerations.

Design methodologies may be derived from theory or based on experience of design practice [SAFE 8, 13 and 14].

Another approach might be to use:

- a database of instructions to command tools which execute specific functions, or
- a database or knowledge base of elements which can be integrated into the courseware [TMIE 1].

2.2 Training Information Systems

2.2.1 Introduction

As the amount of learning material available in Europe grows, it becomes more difficult to locate those resources best suited to satisfy a specific learner need, especially as information about the available material is often scarce. Furthermore, it is important to provide more support for the re-usability of existing material. It is also necessary to reduce the production cost, which is often very high and results in expensive learning materials (see also 2.1.8). Consequently, Training Information Systems (TIS) have

received much attention in several projects of the DELTA Exploratory Action. The basic aim of a TIS is to provide a means for storing and retrieving information about learning materials. The materials themselves can be stored in the system, but this need not be the case, as long as information on where and how to get access to these resources is available. Information about curricula that can be supported by the available materials can also be available in the TIS.

A TIS can be used in different ways:

- Learners can access the TIS in an attempt to find out about resources that satisfy their needs and easy access to the information is of great importance (see 2.2.4).
- It is also possible to link a TIS to an Intelligent Tutoring System that is able to guide users in their search or that can itself select materials on the basis of a student model. In the latter case, selection can either be carried out at an initial stage, before the actual learning process has begun, or during the process itself, depending on the granularity of the courseware descriptions stored in the TIS.
- Tutors can consult the TIS to find learning materials that might satisfy the needs of their students.
- Authors can look for existing learning materials on the topic being dealt with, either to use them in their own courseware or to generate ideas that might be useful in the production of new materials. If segments of existing courseware are to be reused, granularity of the TIS is again a very important issue (see 2.2.2) [ESMBASE 1].

In the following subsections, four basic problems related to the construction of a TIS are considered.

2.2.2 Identification of relevant data

As has been pointed out by a number of projects in DELTA, it is a far from trivial task to identify and structure the data relevant to the different types of users discussed in 2.2.1 [ESM-BASE 1], [EPOS 4 and 6] (where an object-oriented methodology is used to describe some of the relevant data), [SAFE 15], [ACES 1], [MATIC 2] and [CAPTIVE 3].

These data relate to the modelling of:

- the target audience;
- cultural aspects, including (but not restricted to) the languages used;
- the content that is covered;
- the pedagogical setting in which the materials can be used;
- the educational goals;
- the kind of resources that are necessary if one wants to use the materials;
- multimedia aspects, as most learning materials combine different media (see also 2.1.6).

To achieve re-usability of learning materials, fine granularity is necessary in the description of available resources, as authors of new material will most often want to include only parts of the learning materials in their products. This implies breaking down the available materials into units that are meaningful on their own. However, it is often far from clear how far this breakdown should be pursued and what exactly constitutes a meaningful unit. Not only the unit itself, but also the links between different units have to be modelled [ESM-BASE 1]. An attempt was made to set up a prototype database of learning material with some 800 ULMs concerning plate tectonics [ESM-BASE 1].

In [CAPTIVE 3], a database containing factual information on the video material is linked to an image-base which stores still and moving images. The image can be retrieved and displayed either locally or remotely. In the latter case, the image is transmitted by satellite or through a cable network.

2.2.3 Data modelling and storage

As mentioned in 2.2.2, storing data is a complex matter when using existing database technology. State-of-the-art databases are mainly intended for massive storage of well-defined data with clear and simple interrelationships, such as those found in administration or airline reservation systems.

The strengths and weaknesses of the classical data models (hierarchical, network [EPOS 7] and relational [EPOS 2]) have been explored and several of the commercially available DBMS have been evaluated in the light of the demands imposed by a TIS. A commercially available relational DBMS (DB2) has been used to set up a prototype database on audio-visual material.

The OO paradigm has been put forward as a convenient model for the data stored in a TIS [ESM-BASE 2], [EPOS 8], [CAMCE 4]. There is a general consensus that the use of OO databases could contribute significantly to re-usability, but an evaluation of available OODBMS suggests that a fully matured commercial product does not yet exist. A set of basic functionalities that an object oriented TIS should support has been defined [EPOS 5], [CAMCE 1].

As local and wide-area networks proliferate, access will be essential, and distributed database technology will be important in the construction of a TIS [EPOS 1].

2.2.4 Access methods

As mentioned above, the data stored in a TIS need to be easily accessible to various users. Traditionally, a distinction is made between the following two access methods:

- navigation: the user follows the links between the different pieces of related information;
- set-oriented query: the user states what kind of material should be retrieved from the TIS, without specifying how the material should be retrieved, as this becomes the responsibility of the DBMS.

It is clear that the navigation paradigm uses concepts and techniques very similar to the ones used in the hypermedia community (see 2.1.6). Set-oriented querying is mainly used in relational systems with languages such as SQL. The integration of both paradigms is an important subject in database and hypermedia research, as they to offer complementary services. Low-level functionalities for both access methods are specified and although these are not integrated, switching between the two paradigms is included [EPOS 5].

Both paradigms may be combined: a local advisory system supports navigation in a structured representation of the content domain, enabling a user to specify the topic. A query mechanism allows the user to specify the kind of information to be retrieved on material that deals with the topic. The local system translates the results of both actions into a SQL query that is sent to a central audio-visual material database [CAPTIVE 3].

As far as navigation is concerned, a distinction is made between two possible modes [ACES 1], depending on whether the information provided by a user model is taken into account or not. Attributes describing properties of a course provide different viewpoints for each class of user. Thus, the information provided to users will depend on the user's category. A prototype of the browser was presented, together with several typical scenarios [ACES 3].

A view facility is provided that allows users to construct a personal viewpoint on the TIS, similar to the view mechanism provided in relational database management systems [ESM-BASE 1]. The functionalities a navigation component ought to provide were specified [MATIC 2].

Aspects of learning materials which are suitable for some cultures but not for others, need to be described in the TIS, as mentioned in 2.1.2. It is also important to take these aspects into account within the TIS itself, as this system will be used by people with different cultural backgrounds. One of the problems is the support for different languages for the retrieval of information; translation, although important in itself, will not suffice. Regarding other cultural aspects, the concept of 'late binding-in' might be useful: it refers to a separation between those features of learning materials that are dependent on a specific culture. If the late binding-in turns out to be feasible (and this is uncertain), different versions of the culture-dependent part could be designed for each culture. The culture-independent component could then be combined at run time with any of these versions, resulting in learning materials adapted to a specific cultural community [ESM-BASE 1].

Another problem relates to the inclusion of existing learning materials. Components of these resources that are meaningful on their own will have to be identified and described. Any support in this respect, offered either by the TIS or a component linked to it, will be very valuable.

2.2.5 Architecture

The final implementation of a TIS should be available to hundreds of course material producers and should be accessed by the many different sites, located throughout the European Community. The possibility to access transparently all the TIS' as a single enormous database is still beyond the state-of-the-art in a multi-vendor open environment. Therefore, the approach [EPOS 13] tried to find a balance between the requirements for transparency and usability and the use of stable technologies. The ISO Remote Database Access protocol and the ISO X500 directory function were selected for implementation.

This approach does not preclude the possibility of evolving to a fully transparently distributed architecture [EPOS 13].

2.3 Remote course delivery systems

2.3.1 Satellite broadcasting

Satellite broadcasting as a medium for remote course delivery was dealt with by a

number of the consortia involved in DELTA.

The term "satellite broadcasting" relates to:

- programmes intended for wide audiences and transmitted within entertainment-led services, i.e. "broadcasting" strictu sensu (CHANNEL e);
- "narrowcasting" experiments enabling access only to a restricted audience through "encryption" and "conditional access" (eg. for doctors having subscribed to the service [SAT-DOC];
- closed audience groups where only the members of a course production team have any interest in receiving the transmissions (point to point/point to multi-point) [JANUS].
- Video frame synchronous addressing is a more precise and flexible means of "beaming" video images to specific individuals; and with much greater potential in the educational environment than conditional access methods. Conditional access is aimed at controlling the ability of a receiver station to receive images and limiting this to people who have paid the requisite fee. Frame-addressing permits images to be sent on demand to a wide selection of individual workstations, selecting the images at a video frame level (i.e. the response can approach 25 changes per second), enabling simultaneous use by several hundred users. This approach provides the flexibility required to make broadcast systems interactive [CAPTIVE 6].

The different projects selected the satellite service and transmission standards according to their specific requirements:

- CHANNEL e using PAL is the logical consequence of its option for a "broadcasting" service on the ASTRA satellite with its pan-European footprint;
- SAT-DOC tested various satellite and terrestrial - including cable - systems on their transparency for its "VIDEOLINK"-narrowcast downloading system;
- CAPTIVE needs OLYMPUS-EUROSTEP pan-European footprint and experiments with the potential of D2MAC transmission technology for single frame addressability.
- JANUS selected EUTELSAT as its first choice, as a result of a comprehensive analysis of the suitability of European satellites (ASTRA, OLYMPUS, EUTELSAT)

specification requirements were :

- pan-European coverage;
- earth stations of small size and low cost;
- direct terminal to terminal voice and data communication [JANUS 1].

The role satellite transmissions played varied from providing a delivery system (broadcasting in CHANNEL e, videoconferencing in LAT and "narrowcasting" in SAT-DOC and CAPTIVE) to giving access to a network for remote collaborative authoring [JANUS]. CAPTIVE initially focused on interactive delivery of still frames but has developed its network more specifically as a tool for collaborative authoring. Nevertheless, in the long run it intends to use OLYMPUS and (later) commercial satellites to transmit the educational videos made. Future implementation must take into account the regulatory and legal positions with respect to copyright, etc.

Satellites have been used for various specific purposes which led to a variety of technologies being added to the satellite transmission.

The CHANNEL e project was mainly concerned with programming aspects of educational and information broadcasting.

It has investigated the potential market in relation to the ASTRA satellite footprint and the transmission standards PAL versus D2MAC and opens some perspectives on future developments for multiple sound channels (as it is technically possible to broadcast one picture signal with more than one sound carrier, so that a programme is understandable by a wider audience) and high definition broadcasting [CHANNEL e 3].

The SAT-DOC project was concerned with the broadcasting of medical educational video programmes which would be down-loaded to specified customer terminals. These terminals would consist of a TV receiver with a specific encryption system, and a video-cassette recorder with the facility to auto-record broadcast material in response to a transmitted signal. A second phase of the project develops a unit incorporating a computer and modem arrangement to provide electronic feedback to the service provider for monitoring and accreditation purposes. An enabler at the service-suppliers location allows for insertion of management data into the tape prior to transmission. Experimental transmissions have been successful.

The dedicated VIDEOLINK technology will have to prove its ability to be integrated into the forthcoming European standard for encryption of and conditional access to satellite and cable broadcasts [SAT-DOC 2].

In developing its model of the telecommunications links needed to provide a remote video courseware production and delivery system for the European Community,

CAPTIVE proposed to take advantage of the Community-wide access available by using direct broadcasting by satellite (DBS). Terrestrial links would be used for feedback and control purposes between remote sites and the network hub and/or other remote sites. Such a network structure would facilitate interactive, audio-visual conferencing, which would be very useful for collaborative course-material production as well as for course delivery. The OLYMPUS satellite is accessed via the LIVENET fibre optic network at London University, which links the central picture store to the uplink.

The system has demonstrated in the experiments that it can be used as a delivery system as well as for pre-delivery conferences. Simultaneous audio-conference and satellite transmission took place where the consultation was effected over the audio link and images, both still and moving, were selected and transmitted on demand [CAPTIVE 2] by satellite from the image store.

The JANUS project for the establishment of a joint academic network using satellites took the form of a feasibility study on the practicability of using a satellite-based telecommunications network to link participating sites (teaching institutions) for co-operative course production.

However, the consortium envisages eventually using the network to distribute the final version of the course material and also for tutoring purposes.

A feature of the JANUS network is that the inter-site communications links will be completely by satellite, in a mesh configuration; connection to local on-site communication networks (LANs or PABXs) is envisaged. Shared two-way voice and data links will allow for use of the network for distance teaching as well as for the design and production phase. It is considered that a one-way video capability can be added to JANUS microterminals relatively inexpensively, thus allowing for a more profound educational experience.

Satellite access methods and link management functions are important technical aspects which JANUS has had to address in the feasibility study [JANUS 1].

From a telecommunications technology perspective, the LAT project is concerned with the relationship between the telecommunications transmission medium chosen, eg. satellite communication, and the learning results. DBS is considered to be suitable for training activities such as language courses, management seminars, intercultural adult education, and the training of migrants and immigrants. The acceptance by participants in a set of videoconference experiments carried out by the project was generally satisfactory, but there were some technical problems (sound and vision quality) which emphasised the importance of interference-free and uninterrupted telecommunications links for efficient distance learning activities [LAT 1].

Cross-cultural issues

The visibility of satellite transmissions across the borders of nations, linguistic groups and larger cultural entities not only demands multi-lingual programming but also immediately confronts the cross-cultural dimension; multi-lingual broadcasting is performed by CHANNEL e, SAT-DOC and CAPTIVE using various combinations of (teletext and/or "burnt in") subtitling and multiple audio channels (lip-synch "dubbing" or not).

No standards or widely accepted guidelines for educational multi-lingual broadcasting have been produced yet.

Cross-cultural issues arise both on the content matter level (eg. acceptability of medical procedures or preventive prescriptions in SAT-DOC and CAPTIVE) and in the field of methodology (eg. teaching styles) [OLE 2]. More work remains to be done in this domain.

The problem of multiple European character sets (totalling 256 or more characters for Europe, including Central and Eastern Europe) needs a more complete and standardised solution than the ones commercially available today [JANUS 1].

Production and presentation standards for educational broadcasting and teleconferencing have been addressed by CHANNEL e, SAT-DOC, CAPTIVE and LAT, but need to be further developed [LAT 1].

2.3.2 Data voice video communication

The contribution of telecommunications to distance learning is made very clear in the OLE project. Although remote course delivery can be achieved by other means, the impact of the real-time interaction together with the multimedia delivery capabilities achievable using the voice, data, image and text capabilities of modern telecommunications networks, greatly facilitates the learning process.

In the OLE experiment an on-the-job training course was delivered reciprocally between Denmark and Portugal using telephone, facsimile, slow-scan TV, electronic-blackboard, computer conferencing, data-base and video-disc.

The training courses were considered successful by all concerned. However, even though the technology required for such courses may function as planned, there are many human factors which can prevent the courses from being as successful as they could be [OLE 1].

OLE and CAPTIVE have developed hybrid (combining analogue and digital technol-

ogy) networks and procedures to simulate (in a non-standardised way) functionalities expected to become widely available if and when (broadband)-ISDN will be fully implemented [OLE 3], [CAPTIVE 4].

The video and audio capability as presented by CAPTIVE could be added in a useful way to the text and voice communication network which JANUS is proposing for collaborative and distributed authoring [CAPTIVE 6], [JANUS 1], figure 2.10.

The delivery of courseware via telecommunications at a European level raised a number of operational issues, the most important one being the billing system which in turn needs a fairly sophisticated security system. The framework of such a monitoring system is extensively described in [EPOS 15].

2.3.3 Tutoring and Monitoring

Interpersonal communication

In a distance learning network one needs to identify why and when a user needs to interact with other persons and what are the related functionalities of a mailing/computer conferencing system [EPOS 14].

Some projects evaluate computer conferencing systems as a means for group learning. The OLE project compares current systems in terms of a variety of attributes, including support for group communication [OLE 2]. It also uses computer conferencing for human tutoring.

The JANUS feasibility study analyses use of computer conferencing for collaborative authoring. It concludes that the conferencing structure is effective in supporting discursive needs, but that most current systems are inadequate in terms of overview facilities. In the latter context, the project points to **list servers** which automatically forward messages to selected team servers according to a stored list of addressees [JANUS 1].

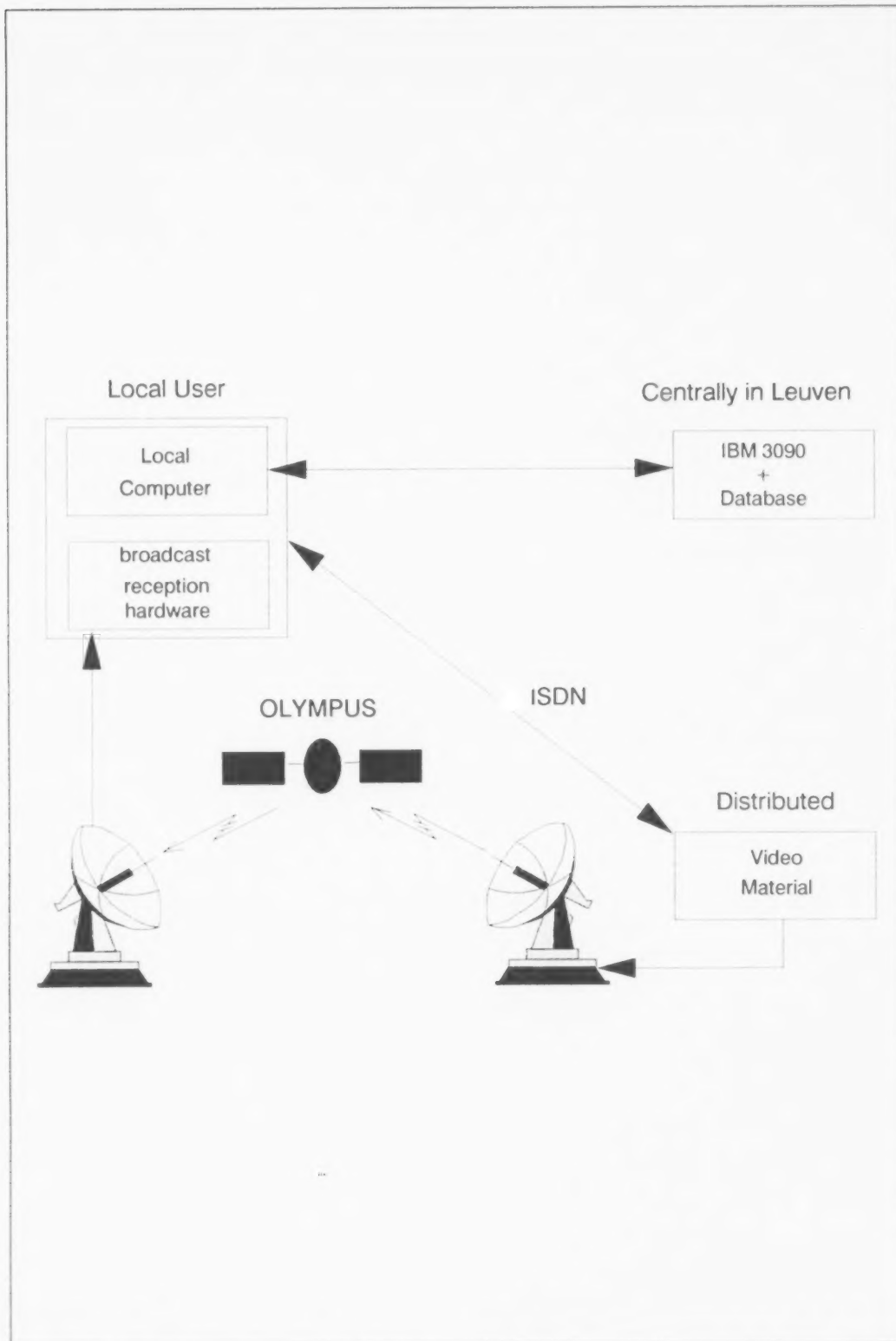


Figure 2.10: Collaborative and distributed authoring [CAPTIVE 6]

Guidance system

In addition to browsing and free navigation in a database of learning material, the need for a sophisticated guidance system was identified to support the management and the use of curricula and teaching plans for a wide range of users like Open Universities, public services and large companies. The general requirements of such a system is described in [EPOS 12].

The current prototype is limited to the specific need of corporate training where 3 classes of end users were identified:

- The central training department which is in charge of planning and managing the training activities and of defining the curricula.
- The local training coordinators who help to define individual teaching plans.
- The learner who will be supported by the system to go through a specific learning path according to well-defined learning goals.

In another approach to the Guidance System, the description of the learning material is made according to a conceptual model which enables the organisation of educational material at the curriculum level. The system behaves like an Intelligent Tutoring System which teaches the learner how to proceed in order to reach specific training objectives. In other words the system teaches about meta-knowledge and therefore contributes to the comprehension by the learner of its own teaching plan [EPOS 14].

In addition to providing tutoring and guidance support to a group of learners, the Team Server in [EPOS 9] also provides services for co-operative work (eg. group access to an information resource), inter-personal communication tools, and other group support facilities (eg. user authentication, name service, message transfer).

3. Methodologies for Delivery of Training.

3.1. Models and Methodologies

The research and development results of the Exploratory Action projects described in Part 2 of this report rely on different models and methods for delivery of flexible and distant training. These models and methodologies serve as a framework and steer the ongoing R&D on delivery systems. Special reference can be made to studies on:

- decision making in adaptive learning [ACES 2],
- integration of different didactic (cognitive apprenticeship, discovery, abstraction, successive refinement) and assessment (practice, direct, Socratic diagnosis, discovery) strategies [AAT 3],
- users' patterns using CAI [TMIE 3] and mailing expert systems [EXVOC 1].

Models and methodologies to measure the effectiveness and quality of training delivery systems were few. OSIRIS developed a dynamic model of effective learning relying on user and market requirements (individual, group, organisational, society) and learning purposes (information versus communication). Three different levels of effectiveness are considered: cost, learner and technology assessment [OSIRIS 6].

The TMIE project constructed factors, criteria and metrics to be used for evaluation of training products at any stage of the training cycle. This evaluation approach has proven to be very useful on a try-out of two prototypes. It resulted in concrete recommendations for improvement of the use of the training systems [TMIE 3].

Due to the exploratory character of the DELTA projects, only a few results on evaluation and experimentation (of flexible learning systems) were obtained. TMIE found, for example, a significant positive effect of peers in using CAI. There is a considerable improvement of learning results due to the grouping of learners. Such an improvement increases with the degree of abstraction of the learning content [TMIE 3].

For distance learning, several Action Line III projects tested and evaluated different

delivery systems based on either one-to-many, one-to-few, one-to-one or many-to-many interaction models.

Good case studies of qualitative educational and training systems developed outside the DELTA programme in Europe were collected by PRECISE and EIOL [PRECISE 3, EIOL 1]. Other projects also researched the state of the art, within their specific R&D domain. These overviews illustrate the importance of basing R&D on explicit methodologies as well as including adequate evaluation strategies.

3.2. Evaluation and Assessment

The experiments were engaged in various options on pedagogic, organizational and technical aspects of the delivery of training which allowed for various degrees of teacher/learner interactivity; this then led to a variety of ways in which the evaluation and assessment issues (implicitly or explicitly) could be addressed.

CHANNEL e's experiment on the delivery of training to a broad audience (as the term is understood), exploiting the possibilities of satellite broadcasting to reach the widest possible audience, did not use real-time interactivity. This makes audience research, focusing on acceptability, all the more essential. This evaluation was carried out, using a standard questionnaire in the language training context [CHANNEL e 1]. The delivery method was found to be highly acceptable and it increased the efficiency of language acquisition if used as a support medium for the provider of resource material. Even then, it was found desirable to supply printed back-up materials, to keep sessions short, and to ensure that technical quality was high.

SATDOC was experimenting with satellite delivered narrowcasting of video materials with a perspective towards computer-mediated feedback via the terrestrial data network [SATDOC 1]. The context was provided by the up-dating of information to doctors in five European centres.

The most effective pedagogic strategy in this context was judged to be "audit exercises in peer groups". Learners in different settings were asked to examine their work, compare the similarities and differences. The differences were then evaluated for their significance and, if possible, agreement was sought on a protocol for treatment or procedure.

Some other projects field-tested prototypes of multiple technology based approaches to interactivity, either one-to-one ("tutorial model" - CAPTIVE - LAT) or many-to-many ("Seminar model" - LAT - OLE).

The CAPTIVE project explored, inter alia, the instructional strategies suitable to a full-bandwidth two-way video environment, supported by "off-the-shelf" courseware.

It concluded [CAPTIVE 2] that this environment is best for deductive expositions of topics, particularly when high-quality visual material is used. Interaction levels were inversely proportional to the group size of learners.

The LAT project carried out seven experiments with this medium, particularly to explore the concept of the 'virtual classroom', tutor-learner interactions and collaborative approaches to corporate training. Evaluation was by means of questionnaires, participational observation and expert interviews [LAT 1]. The groups consisted of 10 learners.

Experimentation in NAT*LAB was used to assess the quality of training software and incrementally refine its functionality [NAT*LAB 4]. A three-phase experimental stream was designed and implemented, which consisted of a pre-experimental review of interface requirements for training systems, followed by naturalistic observation studies based on prototype knowledge acquisitions systems for student errors. The final phase called for specific experiments to be carried out on the use of the developed prototypes. The results of this work allowed the iterative development and improvement of the prototype systems and confirmed the value of the "inverted dialogue" approach.

Of the educational strategies explored, simulations, role-playing and presentations were found to be most effective in language learning and management training contexts. Although these strategies were conceived in the context of "virtual classroom" experiments, they did not include the use of asynchronous media, such as electronic mail or computer conferencing. In a tutorial context, the importance of high technical quality and of the need for pre-circulated documents have emerged. In the corporate skill training context, the results of the experiments point to the advantage of this medium in requiring a higher degree of mental concentration on the part of the trainee, leading to more efficient learning for a period, after which fatigue sets in.

Overall, the experiments pointed to the educational acceptability of video conferencing in a corporate training situation, but also to a potential improvement if the video-plus-audio link were to be up-graded to a broader multimedia environment. In the seminar model in particular, more complementing communication means should be provided (fax, telewriting, joint editing, etc.).

In terms of cost-effectiveness, however, the approach was not judged to be superior to its alternatives, at least at current telecommunication cost levels.

The OLE project assessed a combination of media, including computer conferencing, telewriting (electronic blackboard) and slow-scan TV in the context of a continuing industrial training project between Denmark and Portugal [OLE 1].

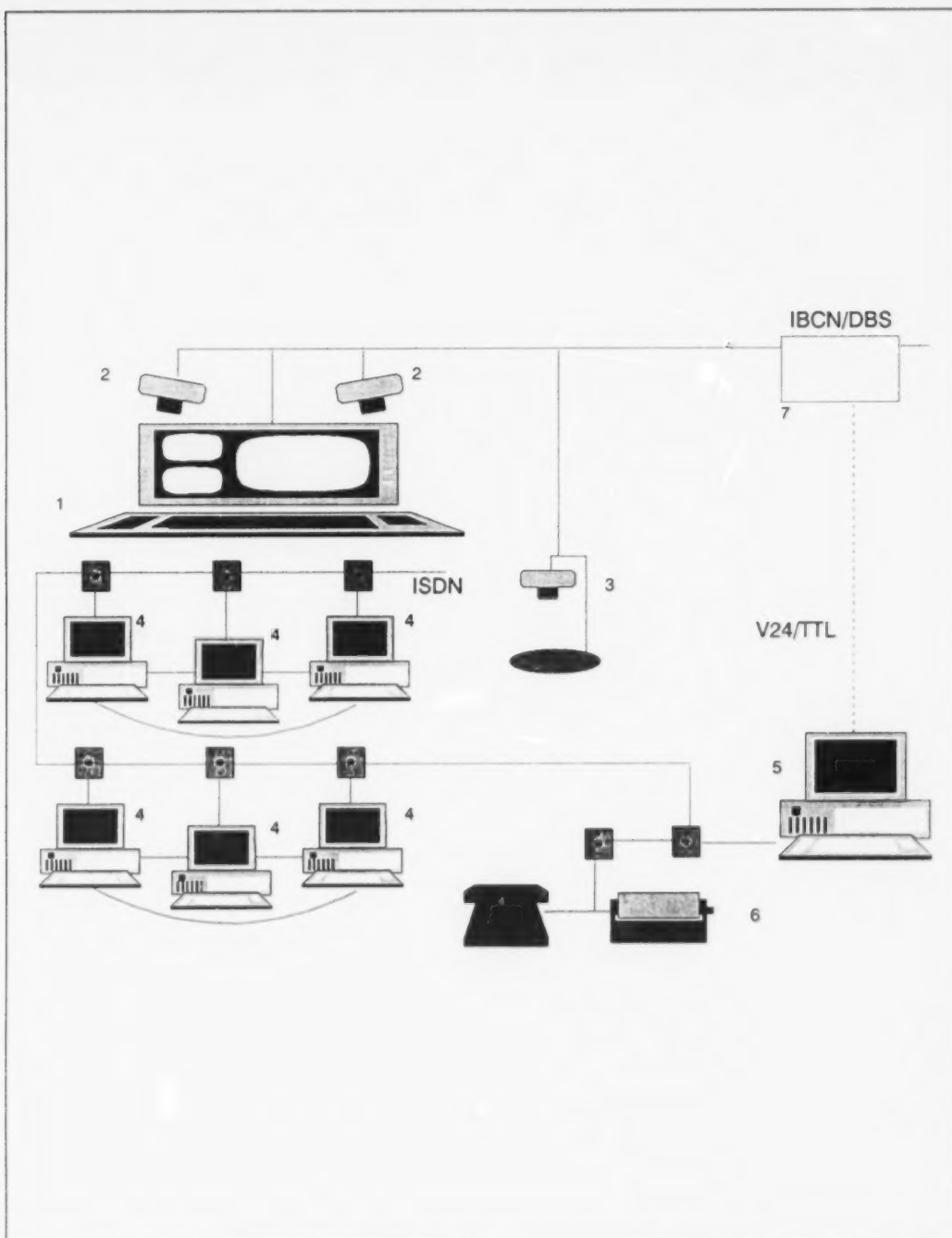


Figure 3.1: LAT Classroom in Corporate Training [LAT]

- Key:
- | | |
|--|---|
| 1 Screen (split screen)/
loudspeakers | 5 Server/terminal control unit for ISDN components |
| 2 Face-to-face camera | 6 Learner document unit |
| 3 Document camera | 7 Subscriber codecs (DBS/IBCN)/terminal control
unit for audio-visual components |
| 4 PC and peripheral devices | |

The results point to the workability of this mix of media from a pedagogical point of view, but not in situations where cross-cultural issues arise in the training process. This implies a need for a thorough training of the trainers in advance of their use of such systems, so that they are able to adapt the communication originating in other countries to the local conditions.

One outcome is obviously common to all projects working on remote interactivity: the high quality of the technology used (including organizational aspects) as well as of the products presented. Otherwise, the technology is perceived as an inhibiting factor by learners, teachers, producers and tutors.

3.3. Description and assessment of experience outside DELTA

Several projects have prepared extensive state-of-the-art reviews, case studies and descriptions of 'good practice' in technology-based learning environments.

In the latter category, the EIOL project reviewed 12 existing open learning organisations [EIOL 1]. It defined 'good practice' in terms of 'the achievement of learning goals through the appropriate application of learning technology', with 'appropriateness' being related to both pedagogic and cost-effectiveness considerations. Some of the delivery models assessed were related to the following topics:

- practical computing and live tutoring in the context of imparting a good working knowledge of computers to accountants;
- the introduction of basic mathematical skills to technology students and the learning of a computer language by university students, all in a distance-learning environment.
- The use of CBT for the dissemination of information on new products and procedures and for flexible simulation in company staff training.
- The use of interactive videotex for the teaching of mathematics to economists.
- The use of video lectures, in combination with printed notes or books, computer-based exercises and electronic-mail based tutoring in providing a comprehensive introduction to expert systems at post-graduate levels.
- The use of interactive video, with printed materials and audio cassettes as a substitute for field-trips in a Masters-level Geology course.
- The use of text and practical experiments in remote training and up-dating of car electricians.
- The use of CBT plus video for staff training in the context of a financial institution.

Factors contributing to the effectiveness of distance learning were examined in a review of 11 world-wide examples by the PRECISE project (PRECISE 3). The cases were studied in terms of:

- educational aims;
- the locus of learning;
- tutorial provision;
- course components;
- management of the learning process;
- pedagogical strategies;
- access;
- performance.

The study distinguishes between effectiveness for imparting knowledge, skills, understanding of attitudes, values and personal qualities. It suggests that awareness courses are mainly good for teaching knowledge and understanding, but not skills; general interest courses are mainly concerned with knowledge; training courses are concerned with skills; up-dating courses deal with specialist knowledge and technical courses with skills and levels of understanding. Capability courses may cover the full range.

The selected examples include:

- self-study material with practical equipment for the introduction of microprocessors to industrial managers;
- computer conferencing-based, in-service training for health professionals;
- CBT with video staff training in the financial sector;
- two-way video conferencing with computer-based exercises for industrial staff and customer training;
- a multimedia university course (using text, computer-conferencing, electronic mail, PCs, audio and video tape) on the introduction of information technology;
- tutored video instruction for post-graduate-level training for industry;
- "intelligent" CBT for staff training in banking;

- multimedia courses in an American community college and in a Canadian open college, in a variety of subjects;
- networked classrooms, with live tutor support for adult courses in technical subjects;
- audio-conferencing for extension studies in an American university.

The study concludes that perhaps the most important factor contributing to the effectiveness of technology-based distance learning is the matching of pedagogical methods to the educational aims of the course and of the learner. For skills and understanding, active learning methods are important. Multimedia learning technology is useful in providing a rich environment which suits a variety of pedagogic and individual learning styles. Finally, the effectiveness of learning technology in distance education crucially depends on the support and positive attitude of the organising body or institution.

Overall, it is very difficult to identify cases of good as well as bad practice. Nevertheless, projects experienced that studying existing applications of flexible and distance learning is a good resource for future R&D.

Annex 4.1: DELTA Projects and Contact Points

D1001: LEAST	<i>Recommendations for definition of European standards in the areas of information representation, user interface and application & exchange protocols</i> Mr. Patrice Le Moing DCS-B/MULT CAP SESA TELECOM Allée de la Croix des Hêtres 5 35018 Rennes F tel: 33 99 63 50 50 fax: 33 99 63 42 77
D1002: OSIRIS	<i>Definition of European technical standards in relation to ADVANCED LEARNING TECHNOLOGY on all ISO/OSI levels within a market integration strategy</i> Mr. Gérard Courtieux SILOGIA 6 Avenue d'Eylau 75116 Paris F tel: 33 1 47 04 20 77 fax: 33 1 47 04 95 38
D1003: ASAP	<i>Prototype architecture & system for a hardware/software-service common applications platform (PETE)</i> Mr. Vartkes Goetcherian Harlequin Ltd Barrington Hall, Barrington CB2 5RG Cambridge UK tel: 44 223 87 25 22 fax: 44 223 87 25 19
D1004: ARTISAN	<i>Specification of a learner workstation for use in Advanced Manufacturing Environments with particular relevance to SMEs</i> Mr. Mike Cooley Technology Division, Greater London Enterprise 63-67 Newington Causeway SE1 6BD London UK tel: 44 71 403 03 00 fax: 44 71 403 17 42
D1005: STARTUP	<i>Audit of the production methodologies and development tools used by main multimedia publishers in Europe</i> Mr. Eric Barchechath OTE 133 Rue de Sevres 75006 Paris F tel: 33 1 40 56 92 12 fax: 33 1 40 56 92 52

D1005: STARTUP	<i>Audit of the production methodologies and development tools used by main multimedia publishers in Europe</i> Mr. Eric Barchechath OTE 133 Rue de Sèvres 75006 Paris F tel: 33 1 40 56 92 12 fax: 33 1 40 56 92 52
D1006: ESSENTIAL	<i>Definition, clarification and elaboration of the PETE concept, based on frameworks and methodologies supporting requirements capture for European training and retaining</i> Mr. Toni Willi MARI Computer Systems Limited Block 3 Sunderland Technology Park Polytechnic Campus Chester Road Sunderland SR2 7PS UK tel: 44 91 510 1375 fax: 44 91 510 1893
D1007: TOSKA	<i>Specification of a multipurpose knowledge based authoring environment for distributed open learning</i> Dr. Harald Mispelkamp Instructional and Diagnostic Systems Dornier GmbH An der Bundesstrasse 31 7990 Friedrichshafen 1 D tel: 49 7545 83 602 fax: 49 7545 84 411
D1008: ACES	<i>Functional and high level design specifications of learner expert system (LEX) based on a multilayer intelligent interaction management system</i> Drs. Tim A.M. Van Dijk Courseware Europe BV Ebbehout 1 1507 EA Zaandam NL tel: 31 75 17 22 01 fax: 31 75 31 15 02

D1009: MATIC	<i>Formal functional specification of an open and modular suite of software tools supporting multiple strategy and multimedia authoring</i> Ms Ruth Wallsgrove Software Engineering Division BHR Group Ltd. Cranfield MK43 0AJ Bedford UK tel: 44 234 75 04 22 ext. 282 fax: 44 234 75 00 74
D1010: AAT	<i>Integrated implementation and functional specification of an authoring toolset</i> Dr. Jean-Louis Leonhardt IRPEACS CNRS 93 Chemin des Mouilles 69130 Ecully F tel: 33 7229 30 05 fax: 33 7833 33 7
D1011: LAT	<i>Functional specifications of learner places in different environments using satellite transmission combined with audio-conferencing</i> Dr. Friedrich von Stachelsky DV-Beratung CONDAT GmbH Alt-Moabit 91 d 1000 Berlin 21 D tel: 49 30 39 09 40 fax: 49 30 39 09 40 30 0
D1012: ESM-BASE	<i>Investigation & prototype of a multimedia database of learning material with varying storage & access possibilities</i> Mr. Giorgio Olimpo Istituto Tecnologie Didattiche Via All'Opera Pia 11 16145 Genova I tel: 39 10 30 88 83 or 36 11 08 fax: 39 10 31 04 66

D1013: CAPTIVE	<i>Research on different potential applications ranging from the transmission of live programs and video-conferencing to the production and distribution of interactive teaching materials</i> Dr. D. Gordon Jameson Audio Visual Department University College London Windeyer Building Cleveland Street W1P 6DB London UK tel: 44 71 3 80 93 20 fax: 44 71 5 80 09 95
D1014: SAFE	<i>The definition of an Open System for Instructional Design (OSID) and the functional design of authoring facilities to be embedded in this OSID, complementary to PETE</i> Drs. W. Bulthuis Philips Information Systems Innovation Centre Eindhoven P. O. Box 80.000, Building WB2 5600 JA Eindhoven NL tel: 31 40 74 49 22 fax: 31 40 74 48 44
D1015: CAMCE	<i>Architectural design of an authoring environment supporting the production of high quality and multimedia courseware</i> Mr. Antonio Ulloa Tecnopolis Csata Novus Ortus IATIN Strada Prov per Casamassima km 3 70010 Valenzano/Bari I tel: 39 80 8 77 02 54 fax: 39 80 65 18 68
D1016: NAT*LAB	<i>To design & develop the shell of a knowledge based system to represent the characteristics of a learner at different stages of understanding during training</i> Prof. Stefano A. Cerri DIDA LAB DIDA*EL srl Via Lamarmora 3 20122 Milano I tel: 39 2 55 18 00 42 or 64 fax: 39 2 55 18 17 51

D1017: EIOL	<i>Studies on favourable conditions and catalogues of good practices</i> Mrs. Dympna Brett SATURN Keizersgracht 756 1017 EZ Amsterdam NL tel: 31 20 38 24 41 fax: 31 20 38 28 79
D1018: ETEE	<i>Identification of contributions and barriers for the uptake of educational technologies by SMEs in 4 European test regions and development of intervention strategies</i> Mr. Roger Balcon Ressources Humaines CRCI 16 Quai Ernest Renaud 44027 Nantes F tel: 33 40 78 32 14 fax: 33 40 44 60 90
D1019: PRO-DELTA	<i>Analysis of high technology training needs of SMEs in Portugal and France</i> Prof. A.S.C. Fernandes FUNDETEC Rua Dona Estefania 78 1000 Lisboa P tel: 351 1/57 79 94 fax: 351 1 525843
D1020: TMIE	<i>Description, architecture & design of a tutoring, monitoring & production system for the DELTA open & distance learning environment</i> Mr. G. Claes MTS BULL S.A. 7 Rue Ampere 91343 Massy F tel: 33 1 69 93 99 83 fax: 33 1 69 93 84 47

D1021: OLE	<i>Functional specifications and development of a learner/teacher station using advanced technology (databases, interactive video, computer-conferencing, courseware, slowscan TV)</i> Mrs. Bente Lausch Center for Fjernundervisning Aarhus teknisk Skole Halmstadgade 8200 Aarhus N DK tel: 45 86 16 61 00 ext. 21 09 fax: 45 6 10 51 35
D1022: CHANNEL e	<i>Cost benefit analysis of multilingual pan-European educational television broadcasts</i> Mr. Philip Crookes European Institute for the Media Univ. of Manchester M13 9PL Manchester UK tel: 44 61 2 73 27 54 or 27 55 fax: 44 61 2 73 87 88
D1023: INTERMAPS	<i>Multimedia information diffusion within DELTA community</i> Dr. W.F. Kugemann FIM - Psychologie Universität Erlangen Nürnberg Maximiliansplatz 3 8520 Erlangen D tel: 49 9131 85 47 36 fax: 49 9131 85 47 38
D1024: EXVOC	<i>Assessment of opportunities and roles of expert systems in vocational training, also considering the role of government and agencies</i> Prof. Luis Valadares Tavares Centro Estudos Problemas Informacao Universidade Catolica Portuguesa Palma de Cima 1600 Lisboa P tel: 351 1 7 26 55 50 fax: 351 1 72 60 546 or 79 34 538

D1025: PRECISE	<i>Launching and animation of ELTA and studies on market, technology and standards</i> Drs. C.G.J. Nagtegaal Project Management Educational Computing Consortium P.O. Box 217 7500 AE Enschede NL tel: 31 53 33 33 67 fax: 31 53 35 24 99
D1026: EPOS	<i>Prototypes & preliminary specifications for a PTT Open Learning Service incorporating a wide range of features and technologies within the scope of DELTA</i> Dr. Ing. Vincenzo De Rosso Direzione Generale SIP-Soc.Ital.Esercizio Telecom. Via Pietro Crespi 1 20127 Milano I tel: 39 2 6 21 30 83 fax: 39 2 2 84 11 00
D1027: SATDOC	<i>Evaluation of satellite educational facilities through a controlled experiment of satellite broadcasting using a Broadband Educational Medical Information Centre</i> Prof. Paul R. Grob University of Surrey Robens Institute Science Par GU2 5HX Guildford UK tel: 44 483 3 80 05 or 3 70 65 fax: 44 483 3 41 54
D1028: OLEW	<i>Implementing an open learning experimental workshop of IT&T using computer and televideo-conferencing and DBS</i> Dr. Ing. Enrico Rovida Educational & New Technology Dept TEAM srl Palazzo Palavicino via Interiano 1 16124 Genova I tel: 39 10 54 36 41 fax: 39 10 54 15 29

CCAM: BIS-FACT	<i>Identification for factors inhibiting the use of distance learning and the actions needed to create a favourable environment (from the supplier as well as the user side)</i> Mr Ronnie Dallal BIS Mackintosh Mackintosh House Napier Rd LO1 1RG Luton UK tel: 44 582 40 56 78 fax: 44 582 45 48 28
CCAM: JANUS	<i>Software specifications and educational and technical requirements of a private voice and data network via satellite</i> Dr. M. Nouri Marconi Communication Systems Marconi house New St CMI 1PL Chelmsford UK tel: 44 245 35 32 21 fax: 44 245 28 71 25

Annex 4.2: Reference to DELTA Exploratory Action deliverables and results

<i>Project</i>	<i>Ref.</i>	<i>Title [project internal reference]</i>
AAT	1	Authoring for CAL [D1]
AAT	2	Authoring requirements for ITS [D2]
AAT	3	Final Report
AAT	4	P. Brooks, P. Byerley: "Some evaluation of a Prototype of an ITS." (Paper in preparation)
ACES	1	Browsing and Selection Services [RS/DS/221 & DD/DS/212]
ACES	2	Decision making for adaptive instruction
ACES	3	Report on Prototyping [DP/DS/215]
ACES	4	Review of User Modelling and Interaction Management for LEX [TR/LE-1/UU.CE.UCD]
ACES	5	Specification of a Prototype for Interaction Management [D/LA/008]
ARTISAN	1	Definition of Standard Training Tools for Industrial Training [DEL1004]
ASAP	1	Active Graphical Browser [DEL20]
ASAP	2	Design Specification of the PETE hypermedia system [DEL10]
ASAP	3	Final Report [DEL22]
BIS-FACT	1	Flexible and distance learning markets: Volume 6B final report [DEL6B]
BIS-FACT	2	Inhibiting factors and the creation of a favourable environment [DEL1-2]
CAMCE	1	Conceptual model of the CAMCE multimedia data base [D10]
CAMCE	2	Design and production of learning material
CAMCE	3	Functional specification of the knowledge base adviser [D12]
CAMCE	4	Report on progress on the CAMCE multimedia database - Analysis of Object Oriented Data Base Management Systems and Hypermedia Systems [D11]
CAMCE	5	The development model of multimedia courseware [D1]
CAMCE	6	User Interface Guide-lines [D4]
CAMCE	7	Functional specifications of a Distributed Authoring Facility based on ISDN and satellites.

CAMCE	8	Functional specifications of Communication Facilities in CAMCE
CAMCE	9	The use of Satellites and ISDN for communication facilities in CAMCE
CAMCE	10	Final Formal Specifications & Architecture
CAPTIVE	1	An intelligent database system of audio-visual material [<i>Ir. E. Duval: Paper presented at DELTA and Beyond Conference, The Hague, October, 1990.</i>]
CAPTIVE	2	Control techniques in a Remote Interactive Environment
CAPTIVE	3	Final Report on an Intelligent Knowledge Base System
CAPTIVE	4	Intermediate report on the Communications Infrastructure
CAPTIVE	5	Intermediate report on the Use of LIVE-NET video cable network
CAPTIVE	6	Networks and Satellite Channels
CHANNEL e	1	Evaluation of languages training programmes broadcast by Channel-e and result of viewer survey
CHANNEL e	2	Evaluation of Language Training Programmes
CHANNEL e	3	Definition of Standards for Educational and Informational Programme Presentation
EIOL	1	15 case studies of good practice [D7]
EIOL	2	European Infrastructure for Open Learning
EIOL	3	Interim report on study of demand for open learning [D2]
EIOL	4	Final Report
EPOS	1	Distributed data base management systems
EPOS	2	Evaluation of relational DBMS
EPOS	3	General Guide-lines, Database controlled Courseware, Producer Environment Tools [D16]
EPOS	4	Information Resource Definition [D1]
EPOS	5	Information Resource Management [19]
EPOS	6	Initial Description Models of Teaching Resources [D5]
EPOS	7	Network oriented data bases
EPOS	8	Object data base management systems

EPOS	9	Team Server Functions and Architecture
EPOS	10	User Requirements for graphics, text, communications
EPOS	11	The Tutoring system of the EPOS project
EPOS	12	Guidance System prototype
EPOS	13	Team server specifications
EPOS	14	Human being in EPOS a contribution to the tutoring package
EPOS	15	Monitoring systems
EPOS	16	The producer environment & facilities
EPOS	17	Personal Mass Storage System feasibility study
ESM-BASE	1	A Conceptual Model for a Data Base of Learning Material (DBLM) [DEL4]
ESM-BASE	2	Analysis of the Object Oriented DBMS methodology [DEL3]
ESM-BASE	3	Model and Prototype of a DBLM [DEL10]
ESM-BASE	4	Multimedia Learning Material Manipulation: On line Integration of Multimedia Units
ESM-BASE	5	Prototype of the User Interface [0.61/DS/R/O1.00/00]
ESSENTIAL	1	A framework for specification of PETE and tools [DEL3]
ESSENTIAL	2	A Functional specification Methodology for Learning Systems Tools [DEL4]
ESSENTIAL	3	A Taxonomic Framework for Learning Systems Tools
ESSENTIAL	4	Requirements Models for PETE [DEL2]
ESSENTIAL	5	Specification of Authoring and Production Tools for PETE [DEL4.1]
ESSENTIAL	6	Specification of Common Tools for PETE [DEL4.3]
ESSENTIAL	7	Specification of Delivery Tools for PETE [DEL4.2]
ESSENTIAL	8	Portable Educational Tools Environment [DEL6]
ETEE	1	Final Report
EXVOC	1	Draft Final Report
INTERMAPS	1	DLT news (6 issues)
INTERMAPS	2	The DELTA Bulletin on Eurokom

JANUS	1	Report on the First Six Months of the Janus Feasibility Study
LAT	1	Exploratory Research on Distance Learning (Part I formal description of 7 Video Conference Experiments; Part II Assessment of the 7 experiments; Part III: Interaction analysis of the 7 experiments)
LEAST	1	Description of LEAST learning system reference model [D7]
LEAST	2	Functional requirements : final synthesis [D14]
LEAST	3	Multimedia and Hypermedia representation [D11]
LEAST	4	User interface standards in a Learning Environment [12]
MATIC	1	A lesson structure knowledge base
MATIC	2	Functional design of editors and browsers at course and goal level
NAT*LAB	1	Multiple Belief Space and Dialogue Management
NAT*LAB	2	New technologies for learner modelling "connections and parallel machines" [ND7]
NAT*LAB	3	Baiardi, Mussardo, Serra and Valastro: "Feedforward layered networks on message passing parallel computers." in E. Caianiello (ed.): Proceedings of the Italian Workshop on parallel architectures and neural networks (1990).
NAT*LAB	4	The Methodology for the Acquisition of Student Models [ND8]
NAT*LAB	5	Adaptability of User-System Dialogue [ND5A]
OLE	1	Organisation learning in enterprises. Evaluation report of a full-scale multimedia experiment
OLE	2	Comparison of Computer Conferencing Systems
OLE	3	ISDN perspectives for Distance Learning
OLEW	1	Final Report
OSIRIS	1	Characteristics of current and emerging ALT use [DEL3]
OSIRIS	2	Characteristics of Interoperability Environments [DEL2]
OSIRIS	3	Standards Recommendations Summary
OSIRIS	4	The economics of ALT [DEL4]
OSIRIS	5	Functional and technical specifications [DEL7]
OSIRIS	6	Psychological aspects of the learner environment [DEL5]

OSIRIS	7	Final Report
PRECISE	1	Computer-Based Systems for Open Learning State-of-the-Art [DEL29]
PRECISE	2	Making/buying strategies on Technology Based Learning
PRECISE	3	State of the art in Open and Distance Education [DEL31]
PRECISE	4	Survey of results on information dissemination
PRECISE	5	Draft Final Report
PRO-DELTA	1	Scenarios for reception of a European Satellite Education Channel in Portugal [DEL6]
PRO-DELTA	2	Cost analysis for various Distance Education Scenarios [DEL 7]
SAFE	1	Computer Simulation in an Instructional Context [SIM/21]
SAFE	2	Evaluation of hypermedia learning systems [HYP/10]
SAFE	3	Evaluation of user interface demonstrator [HYP/18]
SAFE	4	Final Report on hypermedia databases [HYP/20]
SAFE	5	Final Report on hypermedia user interfaces [HYP/21]
SAFE	6	Final Report on writing hypermedia material [HYP/19]
SAFE	7	First Intermediate Report on authoring tools for simulations [SIM/10]
SAFE	8	First intermediate report on designing for educational purpose [DEEP/5]
SAFE	9	Graph theory for structuring hypermedia [HYP/11]
SAFE	10	Information in OS-ID [OS-ID/4]
SAFE	11	Initial demonstration of hypermedia database [HYP/13]
SAFE	12	Intermediate report on hypermedia structures [HYP/6]
SAFE	13	Model for instructional design [DEEP/8]
SAFE	14	Model for requirements of a learning material design method [DEEP/6]
SAFE	15	Multimedia data bases [DEEP/9]
SAFE	16	Report on instructional transactions [DEEP/4]
SAFE	17	Specification of navigation tools [HYP/12]

SAFE	18	Tools for the design and development of the user interface of an instructional simulation [SIM/8]
SAFE	19	Toward formalising the components of an ISLE [SIM/20]
SAFE	20	User interfaces for hypermedia [HYP/5.8]
SAFE	21	Learning material development, tools and environments [OS-ID/1]
SAFE	22	de Jong, Njoo: "Learning process involved in learning with computer simulations." NATO/ARW Computer based learning and problem solving, Leuven, Belgium, 1990.
SAFE	23	Heijne, de Jong: "Simulate: simulation authoring tools environment." 3rd European Conference for Research on Learning and Instruction, EARLI, Madrid, Spain, 1989.
SAFE	24	Heijne en van Berkum: "A functional architecture for Intelligent Simulation Learning Environments." DELTA and beyond, October 1990, The Hague, The Netherlands
SAFE	25	General architecture of open systems for instructional development [OS-ID 2]
SAFE	26	Subject matter modelling for open learning material [SMART D1]
SAT-DOC	1	An Electronic Feedback Link from Learner to Tutor
SAT-DOC	2	VIDEOLINK a Functional Specification.
STARTUP	1	Final report
STARTUP	2	Producers Know-How and Practice [DEL3]
STARTUP	3	Who is Who [DEL4]
STARTUP	4	STARTUP - COMNET User requirements [DEL 1]
STARTUP	5	Methodological framework [DEL 2]
TMIE	1	Towards a Courseware Production Language
TMIE	2	Tutoring and Monitoring of a third party application
TMIE	3	On the peer's effect using computer assisted instruction
TMIE	4	Needs analysis for tutoring, monitoring and production
TOSKA	1	Content Structure and Analysis [DEL3]
TOSKA	2	Instructional Concepts Analysis [DEL4]
TOSKA	3	Learner Characteristics Analysis [DEL5]

TOSKA	4	Software & Hardware Analyses [DEL7]
TOSKA	5	Van Maercke: "A Generic Task Model for Instruction" <i>NATO advanced research workshop: Instructional Models in Computer-Based Learning Environments</i> , Twente, July 1-4 1991
TOSKA	6	Report on Validation [DEL11]

**Annex 4.3: Relevant documents issued by the
DELTA office**

- "Communications to the Council concerning R & D in Learning Technology - Developing European learning through technological advance. Progress report 89 and Mid-Term Review"; DE2049 (Final), DELTA Central Office, CEE XIII, November 1989.
- "Impact Assessment and Forecasts of Information and Communications technologies applied to flexible and distance learning, Volume I, II & III"; DE1715A; DE1715B; DE1715C, DELTA Central Office, CEE XIII, May 1990.
- "Proceedings of the workshop Markets and Standards"; DE2211, DELTA Central Office, CEE XIII, Milano, November 1990.
- "R&D in Information and Communication based learning technology, DELTA '90"; DE1858, DELTA Central Office, CEE XIII, July 1990.
- "R&D in Learning Technology, Developing European Learning through Technological Advance, (DELTA - an Exploratory Action) Final report on performance and results"; DE2500, DELTA Central Office, CEE XIII, September 1990.
- "R&D on Telematic Systems in Flexible and Distance Learning, Delta '91 Workplan (Draft)"; DE3000, DELTA Central Office, CEE XIII, January 1991.
- "State of Flexible and Distance Learning Today"; DELTA Central Office, CEE XIII, 1991, in preparation, to be published by J. Wiley.

Annex 4.4: Background references

- "Charting the Courses of Distance Education in a wider Europe"; J. Perriault, CDCC (90) 12, Council of Europe, 1990.
- "Des Satellites pour L'Education et la formation a distance en Europe. Postionnement et conditions d'usage. Rapport Final"; ATENA NO. 45046, CEE DGXIII, August 1990.
- "Electronic Networks for European Distance Teaching and Training"; European Association of Distance Teaching Universities, Heerlen, The Netherlands, 1989.
- "Enseignement a Distance: Examen de la premiere partie de l'etude de faisabilite"; CDCC (90) 12, Council of Europe, 1990.
- "Media and Technology in European Distance Education"; A.W. Bates (Ed.), Proceedings of the EADTU workshop on Media, Methods and Technology, European Association of Distance Teaching Universities, Heerlen, The Netherlands, 1990.
- "Research and Development in Advanced Communications Technologies in Europe, RACE '90"; RACE DGXIII, Telecommunications, Information Industries and Innovation; Commission of the European Communities, OTR 302, March 1990.
- "School and Industry, IRDAC Opinion"; IRDAC REPORT, November 1990.
- "Report Working Group Long Term Developments"; A.R. Trindade (Ed.), European Association of Distance Teaching Universities, Heerlen, The Netherlands, 1988.
- "Skills Shortages in Europe, IRDAC Opinion"; IRDAC REPORT, November 1990.
- "Synopses of Projects and Exploratory Actions, Volume 1 to 8"; ESPRIT DGXIII, Telecommunications, Information Industries and Innovation; Commission of the European Communities, September 1990.
- "Towards a European Electronic University: Technology and Course Design for European-wide Distance Education Courses"; A.W. Bates (Ed.), European Association of Distance Teaching Universities, Heerlen, The Netherlands, 1989.
- "Towards Trans-European Networks for a Community Action Programme"; CEE COM(90) 585 final, Brussels, 1990.

Annex 4.5: Pointers to RACE - Projects

DELTA ACTIVITIES

- 1: Standards and architectures
- 2: Design and production
- 3: Training information systems
- 4: Tutoring and monitoring
- 5: Learner tools
- 6: Remote course delivery/advanced telecommunications

RACE : Project						
1	2	3	4	5	6	
					x	1014: ATMOSPHERIC
				x	x	1015: Domestic Customer Premises Network (DCPN)
					x	1022: Technology for ATD
					x	1049: ATM Concept
		x			x	1061: Distributed Integrated Multimedia Publishing Environment (DIMPE)
			x		x	1062: MARIN-ABC (Application Pilot)
		x				1070: Testing Pay-per-View in Europe (Application Pilot)
		x			x	1073: GEOTEL (Application Pilot)
	x				x	1075: TELEPUBLISHING (Application Pilot)
			x		x	1086: TELEMED
					x	1091: ESP-EBIT Service Project

Annex 4.6: Pointers to ESPRIT - Projects

ESPRIT : Project						
1	2	3	4	5	6	
	x	x		x		280 EUROHELP Developing intelligent help systems
	x	x				2001: Storage Processing and Retrieval of Information in a Technical Environment
x	x					2072: European CAD Integration Project (ECIP)
					x	2054: (5107) Ultra-Wideband Coherent Optical LAN (UCOL-2; UCOL-3)
		x				1059: (2149) Dynamically Adaptable Multiservice Switch (DAMS-1; DAMS-2)
	x	x				2083: Structured Information Management: processing and retrieval
					x	2100: Metropolitan Area Communication System (MAX)
x	x			x		2105: Multiworks
x		x	x	x	x	2109: Telematic Object-Oriented Tools for Services Interfaces (TOOTSI)
			x			2144: Information Technology Uptake Support Environment (IT-USE)
x						2374: Piloting of the Office Document Architecture (PODA-2)
		x		x		2382: Elusive Office (ELO)
		x				2424: Advanced Knowledge-Based Environments for Database Systems (KIWIS)
x				x		2431: Home Systems (HOME)
x	x	x				2499: CD-ROM Workbench (CDR)
	x					2615: Intelligent Training Systems in Industrial Environments (ITSIE)
	x	x				2649: Visual Arts Systems for Archiving and Retrieval of Images (VASARI)

ESPRIT : Project						
1	2	3	4	5	6	
x		x				2704: Development of a Dedicated Microprocessor with a Universal Crypto Coprocessor and its Integration into High Security IC-Cards (CRYPTOCARD)
	x					2705: Integrated Toolkit for Highly Advanced Computer Applications (ITHACA-2)
	x					3160: Interactive Dialogues for Explanation and Learning (IDEAL)
	x					3175: Dynamic Interpretation of Natural Languages (DYANA)
	x					3249: European Working Group on Qualitative Reasoning (WGQR)
	x					3267: Use of Children's and Teacher's Explanations in the Specification of Systems of Explanation for Intelligent Learning Environments
x				x		5140: Home Interactive Environment (HIVE)
x			x			5320: Piloting ODA Extensions and their Applications in Systems (PODA-SAX)
			x			5402: Feasibility Demonstration of ODA for Technical Documents (FODATEC)
x				x		5448: Integrated Interactive Home (IIH)
x	x		x		x	5469: Copyright in Transmitted Electronic Documents (CITED)
x	x					5656: Open Standards for Multimedia Optical Storage Environments (OSMOSE-1)

Annex 4.7: List of Abbreviations

AAT	Advanced Authoring Tools (DELTA D1010)
ALT	Advanced Learning Technology
ACES	A Courseware Engineering System (DELTA D1008)
AI	Artificial Intelligence
ARTISAN	Intelligent framework for the industrial environment (DELTA D1004)
ASAP	Animated Specification of a PETE (DELTA D1003)
BIS-FACT	Distance Learning - inhibiting factors and the creation of a favourable environment (DELTA CCAM)
DB	Database
CAMCE	Computer Aided Multimedia Courseware Engineering (DELTA D1015)
CAPTIVE	Collaborative Authoring Production and Transmission of Interactive Video for Education (DELTA D1013)
CBT	Computer Based Training
CCITT	International Telegraph and Telephone Consultative Committee
CD-I	Compact Disc Interactive
CHANNEL e	Development of an Educational and Training Satellite Service (DELTA D1022)
DBMS	Data Base Management System
DBS	Direct Broadcasting
DELTA	Developing European Learning Through Technological Advance
DVI	Digital Video Interactive
EIOL	European Infrastructure for Open Learning (DELTA D1017)
EPOS	European PTT Open Learning Service (DELTA D1026)
ESM-BASE	Educational Systems Based on Multimedia Data based (DELTA D1012)
ESSENTIAL	European Systems Strategy for the Evolution of New Technology in Advanced Learning (DELTA D1006)
ETEE	Educational Technologies for European Enterprises (D1018)
ETSI	European Telecommunications Standards Institute
EXVOC	Expert system contribution to Vocational training (DELTA D1024)
GUI	Graphical User Interface
HyQL	Hyper Media Query Language
INTERMAPS	Interactive Multimedia Access Publishing Services for DELTA (DELTA D1023)
ISDN	Integrated Services Digital Network
ISO	International Standardisation Organization
ITS	Intelligent Tutoring Systems
IT	Information Technology
IT&T	Information Technology and Telecommunications
JANUS	Joint Academic Network Using Satellite (DELTA CCAM)
K-based	Knowledge based
LAT	Learning by Advanced Telecommunications (DELTA D1011)
LEAST	Learning Systems Standardization (DELTA D1001)
MATIC	Multi-strategy Authoring Toolkit for Intelligent Courseware (DELTA D1009)
MMI	Man Machine Interaction
NAT*LAB	(DELTA D1016)
ODA	Office Documentation Architecture
OLE	Organisational Learning Enterprise (DELTA D1021)
OLEW	Open Learning Experimental Workshop (DELTA D1028)
OO	Object Oriented
OOPL	Object Oriented Programming Language
OO DBMS	Object Oriented Data Base Management System
OSI	Open System Interconnection
OSIRIS	Optimum Standards for successful market integration of multimedia on-line services (DELTA D1002)
OS-ID	Open System for Instructional Design

PCTE	Portable Common Tool Environment
PETE	Portable Educational Tool Environment
PRECISE	Promoting and Realising ELTA through Communication and Information Strategies for Europe (DELTA D1025)
PRO-DELTA	Portuguese Research on DELTA (DELTA D1019)
RAVI	Representation of Audio Visual Interactive Applications
SAFE	Standard Authoring Facility Environment (DELTA D1014)
SATDOC	A Satellite mediated controlled experiment of satellite broadcasting for continuing education and monitoring for Doctors (DELTA D1027)
SGML	Standard Generalised Markup Language
SME	Small and Medium Enterprise
SQL	Standard Query Language
STARTUP	Suppliers for Technological Advanced Requirements Through Users Protocol (DELTA D1005)
TIS	Training Information System
TMIE	Tutoring and Monitoring Intelligent Environment (DELTA D1020)
TOSKA	Tools and methods for a Sophisticated Knowledge-based Authoring environment (DELTA D1007)
UI	User Interface

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